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THE EFFECTS OF SMOKING ON PERIPHERAL MOVEMENT DETECTION

ANNUAL REPORT

Craig R. Scoughton and Norman W. Heimstra

August 1975

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U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND

Washington, D. C. 20314

Contract No. DADA 17-73-C-3037 (Year-2)

University of South Dakota
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Two studies were conducted to determine specific aspects of the relationship between smoking and the ability to detect peripheral movement under conditions of low illumination. The first study was designed to determine the relationships between nicotine dosage level and peripheral visual performance. The second study was designed to determine the time/response characteristics of smoking in terms of onset, duration, and decay of effects.

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Analysis of the movement detection data showed high nicotine smokers significantly better able to detect zero movement trials than either the low nicotine or deprived smokers. Analysis of the four movement speeds and the velocity estimation data all yielded nonsignificant differences.

To determine the time/response characteristics of smoking, 40 subjects (20 smokers and 20 nonsmokers) were tested. Smokers appeared under conditions of smoking and smoking deprived. The lounge period was cut to two hours and subjects in both smoking and deprived conditions were deprived for this period. The tasks used were the same as those in the first study with some slight modifications. Upon entering the test room, initial baseline performance measures were taken for all groups. Following the baseline period, smokers were administered a single test session cigarette and all groups were given a series of trials separated into blocks.

Analysis of deviations from baseline for the movement detection showed smokers superior in their ability to detect non-movement of the target. For the velocity estimation task, a significant smoking treatment-blocks interaction was found and subsequent simple effects tests were performed. These results showed deprived smokers to have significantly smaller error after 20 minutes of trial presentations and significantly larger error after 40 minutes.

These data, in conjunction with previous research, indicate a significant effect of smoking on the processing of peripheral visual information. It is suggested that further studies be conducted to more clearly delineate these effects.

SUMMARY

Two studies were conducted to determine specific aspects of the relationship between smoking and the ability to detect peripheral movement under conditions of low illumination. The first study was designed to determine the relationships between nicotine dosage level and peripheral visual performance. The second study was designed to determine the time/response characteristics of smoking in terms of onset, duration, and decay of effects.

To determine nicotine dosage effects, 12 smokers appeared under conditions of (1) smoking-high nicotine, (2) smoking-low nicotine, and (3) smoking deprived. Ten nonsmokers were also tested and compared with the deprived smokers. Under all conditions the subjects reported to a lounge 3 hours prior to testing. If under a smoking condition, high or low nicotine cigarettes (2.5 mg. or 0.3 mg. nicotine) were administered at 20 minute intervals for the entire lounge period. All subjects were trained on the apparatus prior to their first experimental session. For all conditions, subjects were required to perform two tasks designed to measure (1) peripheral movement detection involving the ability to detect movement or non-movement of a peripheral target traveling at one of four velocities or zero, and (2) velocity estimation which required the subject to observe a moving target in his periphery, estimate its velocity, and predict its interception with a stationary target.

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INTRODUCTION

Considerable research effort over the years has been spent determining the impact of tobacco use on a wide range of physiological and psychological processes. Cigarette use in particular has been the subject of a majority of smoking studies and yet remains, for the most part, a poorly understood phenomenon. A comprehensive account of experimental and clinical studies can be found in Larson, et. al. (1961, 1968). The problems associated with isolating a particular smoke component and tracing its effect on particular physiological mechanisms are numerous, especially in the case of human subjects. The alternative for the researcher particularly interested in the implications of smoking on more applicable behavioral manifestations is to observe smoking and its effects on more overt performance criteria. This report is such an investigation exploring the relationships between smoking and the ability to process peripheral visual information.

Previous investigations concerned with the effects of smoking on the reception and processing of visual information have shown a variety of relationships. On a retinal level, Fink (1946) investigated the effects of smoking standard (2% nicotine by weight) and low nicotine (0.2%) cigarettes on the size of the normal angioscotoma. The results showed an increase in the area of the scotoma for the six subjects tested for both nicotine levels, however, the intensity and duration of effects was greater for the higher dosage level. Sheard (1946) tested the effects of smoking two standard cigarettes on the dark adaption of rods and cones, and found a decrement of from 0.25 to 0.75 log units in both. The effect persisted for 15 to 20 minutes and was less pronounced for cones. Larson et. al. (1950) found that the first cigarette smoked after a period of deprivation caused an immediate increase in flicker fusion frequency with a gradual return to baseline after about 15 minutes. The increase was attributed to the nicotine content of the smoke since cigarettes containing less than 0.2% nicotine did not cause the effect.

There are several indications that smoking, particularly the nicotine component of cigarette smoke, produces effects not only at the retinal level; but also effects higher order processing as well. Lambiase and Serra (1957) recorded cortical activity in twenty-five patients before and after smoking, and noted a depression of potential and an increase in frequency of alpha rhythm. These researchers attributed the effect to a double action of carbon monoxide and nicotine resulting in cerebral anoxia (depression of potential) and release of epinephrine (acceleration of frequency). Further evidence of this effect was reported by Ulet and Itil (1969), who found a drop in dominant alpha rhythm (10.5 to 9.5 cps) and significant increases in low frequency bands (3 to 7 cps) in smokers who were deprived of smoking for 24 hours. Hall et. al. (1973) studied the neurophysiological effects of smoking withdrawal and resumption as reflected in the average visual evoked potential (AVEP). A significant decrease of the amplitude envelope was found after 12 and 36 hours of deprivation, with a return to baseline upon resumption. The authors concluded that these changes were consistant with the hypothesis that smoking increases arousal and suggested the possibility that smoking may selectively enhance the perception of weak stimuli. Further details of this investigation will be given in a later section.

The relationship between smoking and peripheral vision in particular has been given attention by Johnston (1965b, 1966) and in this laboratory by Krippner and Heimstra (1969) and Scoughton and Heimstra (1973). Johnston (1965a), while investigating visual search performance as a function of visual field, noted the appearance of a slight loss in some subjects' peripheral acuity after smoking. Pursuing the phenomenon in another study (Johnston, 1965b), it was found that the size of visual fields of four habitual smokers increased 16 to 85 percent after reducing or abstaining from smoking for two weeks. In a third study, Johnston (1966) explored the effects of smoking on visual search performance and found a 34 percent improvement for a group of four habitual smokers who reduced their smoking or abstained from smoking for two weeks.

While the Johnston studies implied a possible relationship between smoking and peripheral acuity, the extremely small sample size severely strained any claims of external validity. Also, the question remained concerning whether the decrement in field could be attributed to the nicotine or non-nicotine components of the smoke. Krippner and Heimstra (1969) conducted a more definitive study to correct for these limitations and ask more specific questions concerning the relationship between smoking and peripheral acuity. These researchers, using an apparatus requiring the subject to peripherally detect the orientation of Landolt C's, tested forty subjects (thirty smokers and ten nonsmokers) over a series of twelve test sessions plus an initial practice session. Ten subjects were placed in each of four treatment conditions: (1) experimental smokers, (2) experimental denicotinized smokers, (3) control smokers, or (4) control nonsmokers. The results showed that abstinence from smoking increased the size of the visual field and after a period of abstinence, smoking reduced field size. Also, on the basis of identical performance of the deprived smokers and denicotinized smokers, it was concluded that smoking effects on vision may be associated with the nicotine component of the smoke.

Little is currently known concerning the possible relationships between static peripheral acuity and the performance of real-world tasks. One area that has received some attention is visual search performance. Erickson (1964) measured peripheral acuity at 3.6 deg., 4.8 deg., and 6.0 deg. from the point of foveal fixation and correlated the results with the time required to find a target embedded in 16, 32, or 48 "noise figures". Significant correlations were found between peripheral acuity measured at 3.6 deg. and 4.8 deg. and detection time for the 16 and 32 figure displays. Johnston (1965a) also investigating visual search performance found a significant relationship between size of visual field and (1) time required to locate targets on a static display, and (2) performance on the Air Force Speed of Identification Test. This Test has been found to be significantly correlated ($r = .61$) with successful aerial observer performance during administration of the Army's Tactical Field Test (Thomas, 1962).

Another aspect of peripheral information processing which is important is the detection of peripheral movement. In many man-machine systems, the ability of the operator to detect and respond to movements peripherally may be critical. Scoughton and Heimstra (1973) conducted an investigation to determine the possible effects of smoking on this critical function. In this study, 25 male subjects (15 smokers and 10 nonsmokers) were asked to perform three peripheral movement detection tasks under several treatment conditions. The first task was designed to determine a subjects' dynamic peripheral threshold by observing a target entering and leaving his field of view. The second task involved a briefly displayed target presented at 65 deg. temporal which moved at one of four speeds (15 min./sec., 18 min./sec., 21 min./sec., or 24 min./sec.) or zero. The third task required a subject to peripherally observe movement of a target across a 10 deg. slot (68 deg. to 58 deg. temporal), estimate its velocity, and predict its interception with a stationary target positioned at 46 deg. The smokers performed these tasks under conditions of (1) smoking-high illumination, (2) smoking-low illumination, (3) smoking deprived-high illumination, and (4) smoking deprived-low illumination. Subjects classified as nonsmokers were tested under a high illumination condition and a low illumination condition. The results for the visual field task showed no differences between smoker and smoker deprived subjects, however, comparison of smoking and nonsmoking subjects revealed a significantly wider field for nonsmokers. The data for the movement detection task showed smoking deprived subjects significantly better than smoking subjects at detecting and responding to movement in the periphery. Analysis for the velocity estimation task revealed that subjects in the smoking deprived group had significantly lower error in their time of arrival estimates under conditions of low illumination. The conclusion of the researchers, based on these results, was that smoking does have an effect on several critical peripheral functions.

This report represents an extension of the Scoughton and Heimstra study. Two separate investigations were conducted in order to more precisely describe the relationships between smoking and the processing of dynamic peripheral visual information. The first study was designed to look at the effects of nicotine dosage level on performance. The second study was designed to determine the time/response characteristics of nicotine as related to performance.

STUDY 1

NICOTINE DOSAGE LEVEL AND PERFORMANCE

INTRODUCTION

As pointed out in several of the previously mentioned studies, the nicotine dosage level used to study a particular phenomenon of interest had a significant impact on the magnitude of observed effects. Fink (1946) found a larger angioscotoma with higher nicotine dosages. Larson et. al. (1950) found flicker fusion frequency affected only with cigarettes containing more than 0.2% nicotine by weight. Krippner and Heimstra (1969), on the basis of identical performance of deprived and denicotinized smokers, concluded that smoking effects on static peripheral acuity may be attributed to the nicotine component of the smoke. The results of these studies, particularly the Krippner et. al. study, indicate that nicotine may be an important parameter in the study of dynamic peripheral vision as well. This study, then, was designed to consider the effects of high (2.5 mg.) and low (0.3 mg.) nicotine dosage effects on visual performance. Two of the tasks (movement detection and velocity estimation) which were found to be significant in showing smoking and deprived smoking subject differences in the Stoughton and Heimstra (1973) study were used with some modification. For the movement detection task, the speeds used were increased and the target placed more toward the periphery. Also, instead of only a "yes" or "no" response criterion, measures of decision latency and confidence level were added. For the velocity estimation task, the same three speeds were used (1.00 deg./sec., 1.20 deg./sec., and 1.35 deg./sec.), however, three exposure distances were used (6 deg., 8 deg., and 10 deg.) instead of only 10 deg.

METHODS

Subjects

The subjects were twenty-two male volunteers from the student population of the University of South Dakota. Twelve of the subjects were chronic smokers (SM), and the remaining ten were nonsmokers (NS). Screening of the applicants was based upon a vision test and questionnaire concerning smoking habits. The visual selection criterion was an acuity of 20/30 or better for both monocular and binocular, uncorrected vision as measured on an American Optical Sight Screener. The smoking criterion was that the applicant smoked at least twenty cigarettes per day and had done so for the previous six months. The nonsmoking criterion required that the applicant had abstained from any form of tobacco for a period of at least one year. Volunteers whose records indicated that they had high blood pressure or were under heavy medication such as barbituates or amphetamines were rejected.

Subjects ranged in age from 18 to 24 with a mean age of 21.4 years. The smokers were scheduled for a training session and three experimental sessions. The nonsmokers were scheduled for a training session and one experimental session. Upon completion of the final session, subjects in both groups were paid ten dollars per session for a total of thirty dollars for smokers and ten dollars for nonsmokers.

Apparatus

The apparatus consisted of an eight foot square table supporting a black metal screen. The screen was 36" in height and formed into an arc encompassing 25 degrees nasal to 120 degrees temporal relative to the subjects' point of foveal fixation. Figure 1 is a sketch of the apparatus showing front and right-side views. Two 1½ inch high slots were cut at subject eye level from 100 degrees to 75 degrees temporal and 68 degrees to 58 degrees temporal. A small point light source was placed in line with the slots at 46 degrees. The point of foveal fixation was represented by a one inch square light panel with two fine intersecting cross-hairs. The subject's chin rest was positioned such that his right eye was 54 inches from all parts of the screen. Figure 2 illustrates the top view of the apparatus and the relative positions of the slots.

Two techniques were used to generate targets for the two tasks the subjects performed. For the velocity estimation task, a horizontal boom was mounted above the enclosures with its pivot point in line with the chin rest extending 2¼ inches beyond the screen. A white rod (.13" diam.) was connected perpendicular to the end of the boom and traveled behind the smaller 10 degree slot. The boom was driven by a variable speed motor which allowed a range of angular target velocities of from 15 min./sec. to 1.4 degrees/sec. A photoelectric transducer driving a frequency counter enabled the experimenter to monitor target velocities to an accuracy of $\pm$ .01 degrees/second.

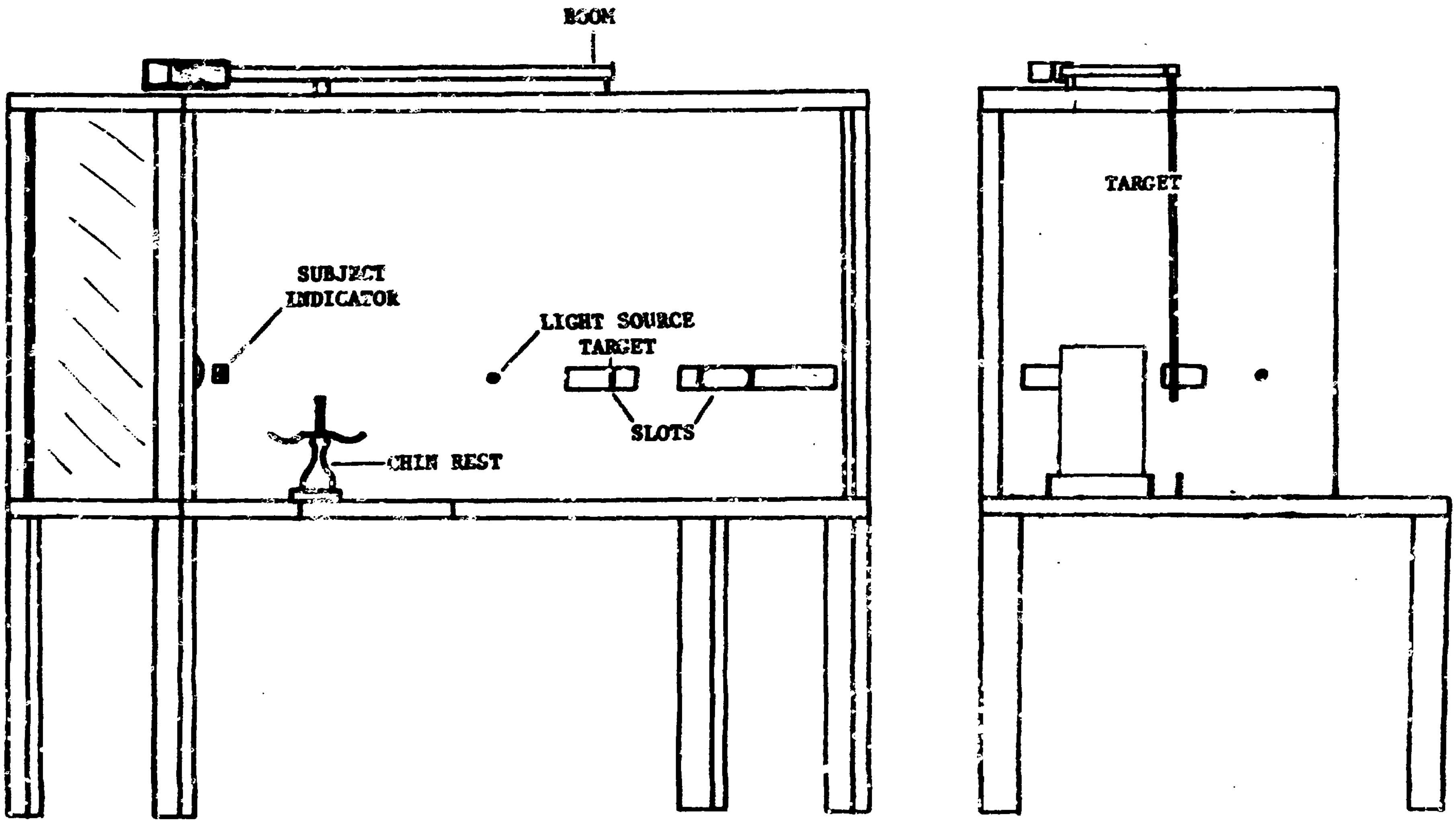


FIGURE 1

FRONT AND SIDE VIEWS OF APPARATUS

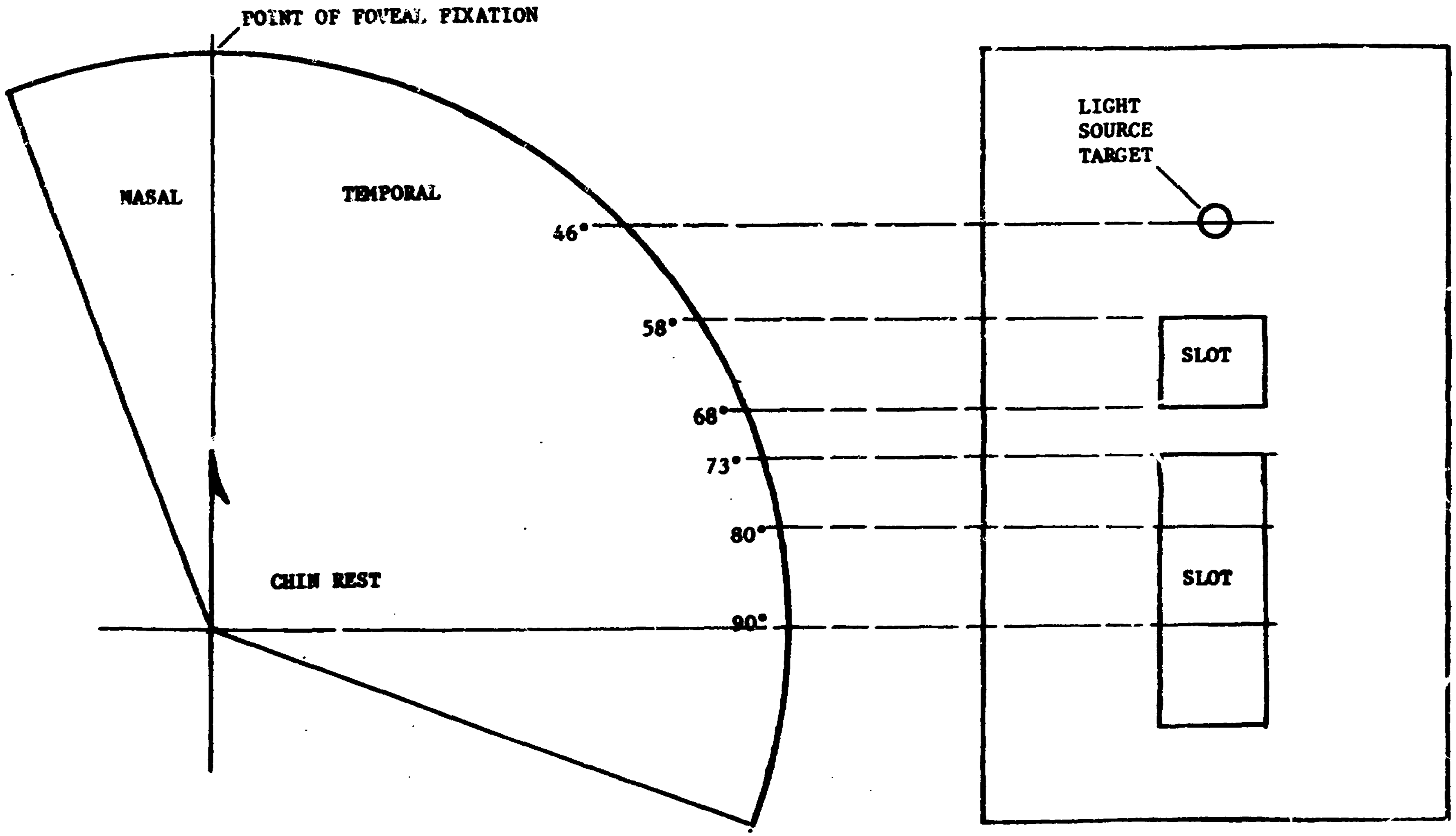


FIGURE 2

SUBJECT'S FIELD WITH CORRESPONDING POINTS ON THE SCREEN

To generate a target for the movement detection task, a cathode ray oscilloscope was used (P1 phosphor, Tektronix Mod. 503). A vertical line was created by driving the vertical deflection amplifier with a 40 khz. sine wave. Horizontal deflection was controlled by a programmable modulus digital counter used as an input to a digital to analog converter.

The control panel electronics were constructed using TTL integrated circuit logic. The panel timer consisted of four seven-segment displays driven by a 10 Mhz. crystal oscillator. Reaction times were indicated to the nearest .01 sec.

Illumination was provided by a GE floodlight located directly behind the subject. This source produced a constant illumination across both slots and could be varied in intensity by a solid-state illumination control. For all training and experimental sessions the background (screen) luminance was -2.2 log foot lamberts and the target luminance was -1.4 log foot lamberts. Luminance measurements were taken using an S.W.I. exposure photometer.

To mask mechanical noises which may have distracted or offered cues to the subject, a low intensity white noise source was used (70 db, re .0002 $dynes/cm^2$).

Task

Movement Detection: This task was designed to determine a subject's ability to make judgements concerning movement/non-movement in his visual periphery. The target velocities (selected through pilot work) were .50 deg./sec., .55 deg./sec., .60 deg./sec., .65 deg./sex. and zero. All trials were initiated with the target at 80 deg. temporal and movement was toward the point of foveal fixation. Previous research (Scoughton and Heimstra, 1973) had shown that the threshold of a target in the temporal field for subjects in all conditions was over 90 deg.

In presenting a trial, the cross-haired indicator was illuminated with a smaller amber light source indicating to the subject that a trial was being initiated. Five seconds later, the amber light was extinguished and a red light was illuminated. At this point, the target either started moving at one of the four velocities or remained at 80 deg. The subject was instructed to respond as quickly as possible by pressing either a "yes" or "no" switch to indicate his decision concerning target movement. After a response was made, the subject verbally indicated on a five-point scale his decision confidence. A one represented little confidence and a five represented a great deal of confidence.

Presentations were broken down into six blocks of twenty trials per block. Between blocks three and four a ten minute break was included to allow smoking subjects to smoke before preceeding with the final three blocks. An equal number of trials were presented for all five speeds.

Velocity Estimation: This task required the subject to peripherally observe movement of the metal rod target across the smaller slot at one of three exposure distances and estimate its time of arrival at a small point light source positioned at 46 deg. Three target speeds were included: 1.00 deg./sec., 1.20 deg./sec., and 1.35 deg./sec. The three exposure distances were: 10 deg. (68-58 deg.), 8 deg. (66-58 deg.), and 6 deg. (64-58 deg.).

Trial presentation was initiated by illuminating the cross-haired indicator. This was the subject's cue to position himself on the chin rest and fixate on the cross-hairs. The target travelled across the slot toward the small light source target. Remaining fixed, the subject was required to press a hand-held micro-switch at the moment he felt that the hidden moving target had reached the static light target. The indicator was extinguished and the subject rested until the next presentation.

The blocks of 36 trials per block were administered with a 10 minute break between blocks.

Measures

Movement Detection: Three measures were used to estimate the ability of the subject to detect movement in his periphery. They were:

1. Hit Rate: This measure was simply the percentage of correct responses at each of the four velocities and zero.

2. Decision Latency: This was the time interval between the initiation of target movement and subject response.

3. <u>Response Confidence</u>: This was the subject's estimate of how sure he was of his response. A five point scale was used with "1" indicating "pure guess" and "5" indicating "absolutely sure".

<u>Velocity Estimation</u>: The measures used as estimates of the ability of a subject to observe a moving target in his periphery, estimate its velocity, and predict its interception with a stationary target were the following:

1. <u>Constant Error</u>: This was a measure of overall or long term accuracy of prediction. It was derived by taking the absolute value of the mean of the signed errors of prediction.

2. <u>Absolute Error</u>: This was a measure of trial by trial or short term accuracy of prediction. It was derived by taking the mean of the unsigned errors of prediction.

PROCEDURE

Each subject was scheduled for one (nonsmoker) or three (smoker) experimental sessions plus a one hour training session which was held the day before the first experimental session. The experimental sessions were scheduled such that the subject appeared at the same time of the day for all sessions with no less than 24 hours and no more than 48 hours between sessions. The entire session lasted for 4½ hours with 3 hours spent in a subject lounge and 1½ hours spent performing the experimental tasks.

The training session was designed to familiarize the subject with the apparatus and the tasks he would be asked to perform during the experimental sessions. All training sessions were administered under the low illumination conditions used during an experimental session. The subject was brought into the room and seated on an adjustable stool directly behind the chin rest. The stool was adjusted for the subject's comfort and the chin rest was positioned such that the apex of the stand was ½" below the lower lid of the right eye. The subject was then asked to put on a patch covering the left eye. A brief introduction of the study and a description of the apparatus were read. If there were no questions, the instructions for the movement detection task were given. If there were no further questions, the noise generator was turned on and the subject was given two blocks of trials (20 trials/block) consisting of a random order of the four velocities and zero. The instructions were then read for the velocity estimation task followed by the presentation of one block of 18 trials (2 trials at each of the 9 speed/exposure distance combinations). At the end of the session, the subject was asked if he had any questions concerning either of the tasks and, if not, was told to report the next day at the time scheduled. He was also informed that no food or beverages would be allowed during the 3 hour period spent in the lounge.

A smoking subject came under a different treatment condition for each of the three experimental sessions he was required to attend. The three treatments were: smoker-high nicotine (MS-HI), smoker-low nicotine (SM-LO), and smoker-deprived (SD). If the subject was reporting under a smoking condition, he was given a cigarette upon arrival and every 20 minutes thereafter for the entire three hour lounge period. Subjects were instructed to smoke in their usual manner. The cigarettes used were obtained from the Kentucky Tobacco and Health Research Institute with the high nicotine cigarettes containing 2.5 mg. nicotine and the low containing .3 mg. nicotine. Both were unfiltered cigarettes containing 30 mg. tar.

A nonsmoking subject (NS), after completing his training session, was scheduled for one experimental session the next day. As in the case of the smoking subjects, the nonsmoking subjects were required to report to the lounge three hours prior to testing.

Both smoking and nonsmoking subjects were required to wear a pair of dark adaption goggles 20 minutes before participating in the test session. If they were also under one of the smoking conditions, they were asked to wear the goggles while in the test room. This was to prevent any light adaption from taking place while lighting or smoking their cigarettes.

Upon entering the test room, an initial 8 minute period was utilized to allow smoking subjects to smoke their first test session cigarette and the experimenter to read the instructions for the first task. After this initial period, the first half of the task was run (15 minutes). Following was a second 8 minute break to allow smokers to smoke their second test session cigarette. The second half of the first task was administered (15 minutes) followed by a third break. During this break, the instructions for the second task were given and the third test session cigarette was smoked. The second task was conducted as the first: 15 minutes, 8 minute smoking break, 15 minute testing period. The entire session lasted for a period of 1½ hours and the order of task presentation was counterbalanced across subjects.

Data Analysis

Movement Detection: The movement detection task was designed to tap two distinctive types of functions which were (1) the ability to detect and respond to movement in the periphery and, (2) the ability to detect and respond to nonmovement. In a classical signal detection sense, these could be considered as "hits" and "correct rejections" respectively. For that reason, the data for the four moving speeds and the zero speed were analyzed separately.

The comparisons of the smoker-high nicotine, smoker-low nicotine, and smoker deprived treatments were made using separate univariate analyses for each of the three variables of hit rate, decision latency, and confidence level. The design included repeated measures with each subject appearing under all levels of each factor. For the zero movement trials, simple one-factor (smoking treatment) analyses were conducted, and for those trials involving target movement, two-way (smoking treatment and speeds) analyses were performed.

In a repeated measures analysis of variance, between subject variability is extracted from the data considerably reducing the error sum of squares. Along with this, however, is a loss in the degrees of freedom used to make up the error mean squared term. If one suspects, as was the case in this study, a high amount of between subject variability; then the repeated measures analysis will, in general, yield more powerful tests of effects than a completely randomized design. A problem, however, associated with repeated measures designs concerns a potential bias in the F test. In most cases, the F test will be positively biased under conditions where the variance of the difference between treatment means is not constant (Winer, 1971). This heterogeneity can appear due to correlations generated by subjects appearing under more than one treatment level. Thus, in order to consider the F test to be exact, the degrees of freedom must be adjusted. It has been shown (Greenhouse and Geiser, 1959) that for a test having (p-1) and (p-1)(n-1) degrees of freedom, an adjustment coefficient for each of these will vary between 1 and 1/(p-1). A conservative estimate can be made, then, that will provide a maximum probability estimate of the null hypothesis. Using the above degrees of freedom, for example, the conservative test would have 1 and (n-1) degrees of freedom. For the purposes of this and the second study, effects found to be significant (alpha = .05) using the standard degrees of freedom were subjected to second test using the conservative. If the results were incompatible (i.e. standard-significant and conservative-not significant), an alpha of .015 was used for the standard test.

For the smoker deprived-nonsmoker comparisons, two procedures were used. For the zero trials, a one-way multivariate analysis of variance was performed using all three variables. For the movement data, comparisons were made by running separate profile analyses on each of the variables. With this multivariate procedure (which assumes commensurable variables) overall tests were made of smoking treatment-speed interaction, smoking treatment effects, and velocity effects.

Velocity Estimation: Analyses of the velocity estimation data were performed to determine whether nicotine dosage is related to the ability to make arrival estimates of a briefly displayed moving target with another stationary target. Three viewing distances and target speeds were used and measures of long-term (constant error) and short-term (absolute error) accuracy were taken for each trial.

As in the movement detection task, the design for the velocity estimation task had smokers (high, low, and deprived) appearing under all three levels of smoking treatment. Separate three-factor repeated measures analyses of variance were performed for constant and absolute error.

For the smoker deprived-nonsmoker comparisons, because of the unequal number of subjects in these groups, separate unweighted means analyses were used for the two variables. The design was mixed with one between (smoking treatment) and two within subjects factors (velocity and distance).

RESULTS

Movement Detection

Analysis of the data for smokers (high, low, and deprived) for speed zero showed a significant smoking treatment effect for the variable hit rate (Table 1). The individual group performance means for this variable were: 80% correct for high nicotine smokers, 65% correct for low nicotine smokers, and 61% correct for deprived

Table 1

MOVEMENT DETECTION TASK SMOKERS (HI, LO, DEP)
SPEED ZERO

	SS	df	MS	F	p >	p <
A		2				
Hit Rate	1.27610		0.63805	5.082	0.015	0.043
Dec. Lat.	0.18918		0.09459	1.102	0.351	
Con. Lev.	1.70866		0.85433	2.331	0.119	
S		11				
Hit Rate	2.92000		0.26545			
Dec. Lat	5.62446		0.51121			
Con. Lev.	1.45534		1.32303			
AS		22				
Hit Rate	2.76211		0.12555			
Dec. Lat	1.88897		0.08586			
Con. Lev.	8.06231		0.36647			

A = Smoking Treatment
S = Subjects

smokers. A subsequent test of the arcsine transformed means using the Newman-Keuls procedure revealed high nicotine smokers to be significantly more accurate than the low and deprived smokers (Table 2). Decision latency and confidence level for speed zero, however, were not found to be significant (Table 1). Comparisons of the three smoking treatments for trials involving target movement yielded significant speed effects for all three variables (Table 1, Appendix)* with improved performance with speed, but no treatment-speed interaction or treatment differences were found.

The tests of smoking treatment differences for smoker deprived and nonsmoking subjects were all found to be nonsignificant for both speed zero trials and trials involving target movement. In brief, the multivariate and univariate tests for non-movement trials showed no differences (Table 2, Appendix). The three profile analyses performed for each of the variables (Tables 3-5, Appendix) revealed no significant treatment-speed interactions or treatment effects. Tests of flatness for the three variables were all found to be significant indicating a differential effect due to speed of the target. Graphs of the three profiles are shown in Figure 3. From these graphs it appears that hit rate and confidence level increased and decision latency decreased with increasing speed.

Velocity Estimation

The results of the analyses for constant and absolute error for the three smoking treatments (high, low, and deprived) showed the smoking treatment main effect and all smoking treatment interactions to be nonsignificant (Tables 6 & 7, Appendix). Similar results were obtained for the smoker deprived-nonsmoker comparisons (Tables 8 & 9, Appendix). While velocity was found to be a significant factor in each of these analyses, with decreased error occurring with increased speed, viewing distance was not.

*Tables of analyses in which no significant treatment main effects or interactions were found, appear in the Appendix.

Table 2

MOVEMENT DETECTION TASK TESTS ON MEANS USING NEWMAN-KEULS PROCEDURE SMOKERS (HI, LO, DEP) SPEED ZERO

Smok. Cond.	Dep	Lo	Hi		
Ordr. Mean.	1.797	1.869	2.228	R	SB Q.95 (R, 22)
Dep		0.072	0.431	3	0.269
Lo			0.359	2	0.222

SB = 0.07554
SB Q.95 (3, 22) = 0.269
SB Q.95 (2, 22) = 0.222

	Dep	Lo	Hi
Dep		--	*
Lo			*

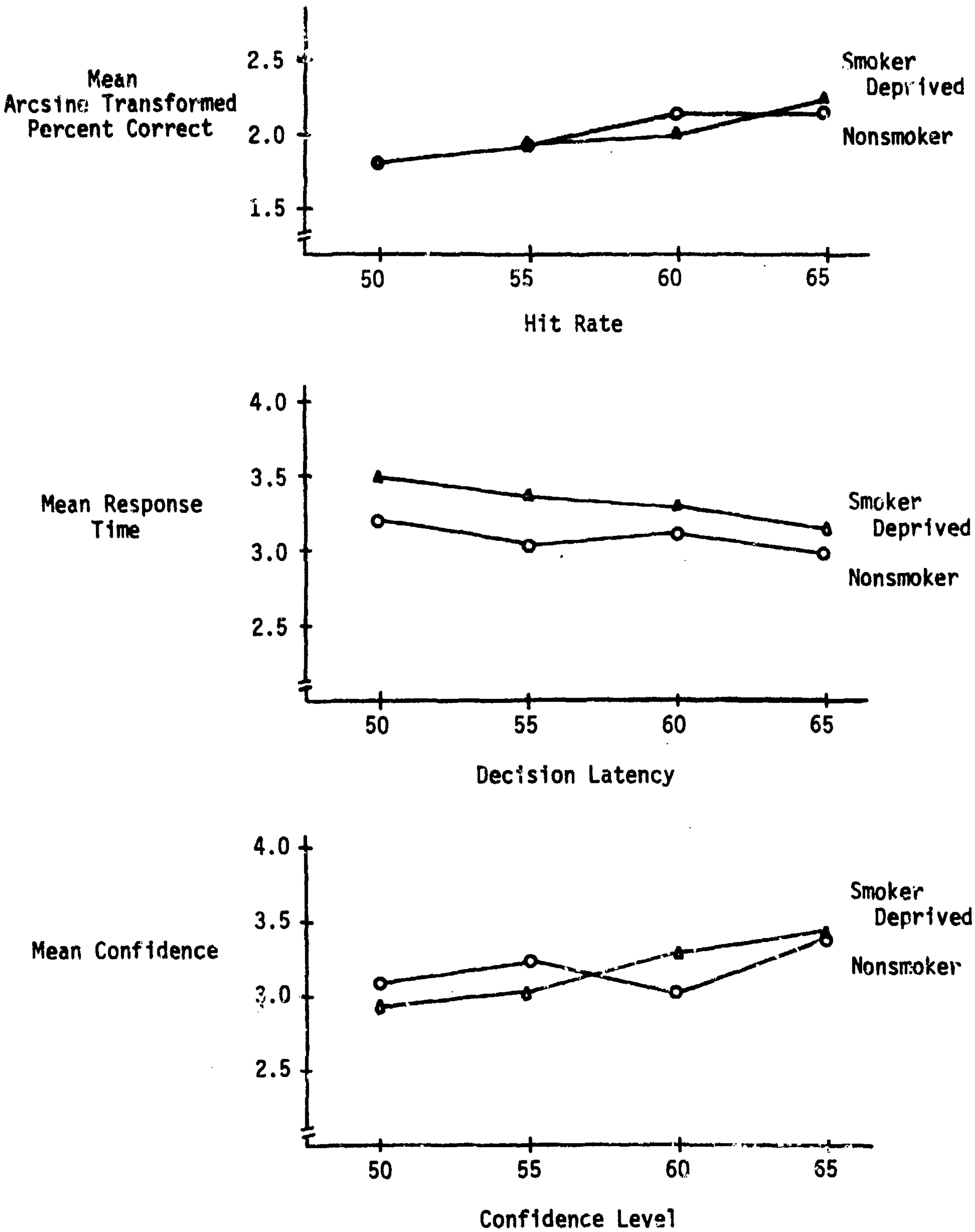


Figure 3

SMOKER DEPRIVED VS. NONSMOKER FOR MOVEMENT DETECTION

STUDY 2

TIME/RESPONSE CHARACTERISTICS OF SMOKING

INTRODUCTION

An important aspect in the description of drug induced behavior is the onset, duration, and decay of effects. In the case of smoking, the particular time/response characteristics are contingent upon the phenomenon under observation. Sheard (1946) found the dark adaption of rods and cones to be affected for about 15 to 20 minutes after smoking two standard cigarettes. Larson et. al. (1950) examining smoking effects on flicker fusion frequency also reported a return to baseline after about 15 minutes. Frankenhaeuser et. al. (1968), however, studying the dosage and time effects of cigarette smoking on hand steadiness, skin temperature, and blood pressure reported decreased steadiness, decreased temperature, and increased blood pressure effects to persist for approximately one hour. Krippner and Heimstra (1969) studying smoking and peripheral visual acuity were able to get a precise time/response measure, however, they concluded that field narrowing occurred within an hour after experimental subjects began smoking.

To determine the time/response characteristics of smoking in terms of dynamic peripheral movement perception, the same two tasks (movement detection and velocity estimation) explored in the first study were used. Pretreatment baseline measures were taken before smoking and used to generate post-treatment deviation scores over a series of blocks.

METHODS

Subjects

The subjects were forty male volunteers from the student population. Twenty of the subjects were chronic smokers and the remaining twenty were nonsmokers. Screening of applicants was based on the same criteria as the first study. The range in age was 18 to 25 with a mean age of 22.2 years. The smokers were scheduled for a training session and two experimental sessions; and the nonsmokers were scheduled for a training session and one experimental session. Upon completion of the final session, subjects in both groups were paid seven dollars and fifty cents ($7.50) per session for a total of fifteen dollars for smokers and seven-fifty for nonsmokers.

Apparatus

The apparatus was the same as that used in the first study with some minor modifications. The speeds for the movement detection task were programmed for zero, .50 deg./sec., .60 deg./sec., and .70 deg./sec. The speeds for the velocity estimation task were changed to 2.25 deg./sec., 2.55 deg./sec., and 2.85 deg./sec. Other parameters such as illumination level, observer-target distance, angular displacements of targets, and target control techniques were the same as those used in the first study.

Tasks

Movement Detection: Four target velocities (0, .50, .60, .70 deg./sec.) were used to assess peripheral movement detection ability. As in the first study, all trials were initiated with the target at 80 deg. temporal and movement was toward the point of fixation.

A trial presentation consisted of a three second warning, five seconds of target movement, and a four second pause before the next trial. The subject was instructed to respond "yes" or "no" on a switch panel and report his decision confidence on a scale of one to five (one = low, five = high).

During an experimental session, ten blocks of trial were presented with a block consisting of 20 trials. The first two blocks were pretreatment blocks used to determine individual performance baselines prior to smoking. The eight post-treatment blocks were used to establish onset, duration, and decay of smoking effects.

Velocity Estimation: Three target velocities (2.25, 2.55, & 2.85 deg./sec.) were used to assess target interception estimates. The target exposure distance was held constant at 8 degrees (66-58 degrees temporal) and the concealment distance was held at 12 degrees (58-46 degrees temporal). In all trials the target traveled toward the point of fixation.

A subject was instructed that when the cross-haired indicator was illuminated, he was to position his chin on the stand and fixate on the cross-hairs. The target would travel across the slot and he was to indicate the arrival of the hidden target at the point marked by the small light by pressing his microswitch. He was also told that he was to remain fixed on the cross-hairs until after his estimate had been made.

During a session, five blocks of trial were administered with 18 trials per block. The first block was used to establish a pretreatment baseline, and the remaining four to estimate smoking effects.

Measures

The measures used in the movement detection task were identical to those implemented in the first study (i.e., hit rate, decision latency, and response confidence).

For the velocity estimation task, measures of constant error and absolute error were derived as defined in the first study.

PROCEDURES

Each subject was scheduled for one (nonsmoker) or two (smoker) experimental sessions plus a 40 minute training session. Ten smokers and nonsmokers performed the movement detection task and the remaining ten smokers and nonsmokers performed the velocity estimation task. All subjects reporting for two sessions were scheduled at the same time of the day with no more than 48 hours between sessions. An entire session lasted for 3 hours with 2 hours spent in a subject lounge and one hour undergoing testing.

The training session was conducted in a similar fashion to that of the first study with the exception that subjects were trained to perform only one of the tasks. An illumination level identical to the experimental session was used with subjects having sufficient time to adapt while the apparatus was being described and specific task instructions were given. All subjects were required to wear patches covering their left eye. After the instructions were read pertinent questions were answered and the training trials initiated. For those subjects performing the movement detection task, two blocks of 20 trials per block were given totaling 10 trials at each of the four velocities. Those subjects performing the velocity estimation task were given one block of 18 trials with 6 presentations of each of the

3 velocities. At the end of the session, the subject was reminded of his schedule and informed that no food or beverages would be allowed during the lounge period.

A smoking subject appeared under both the smoking (SM) and smoking deprived (SD) treatments. Regardless of treatment assignment, subjects were deprived of cigarettes during the 2 hour lounge period. This was done to insure the validity of the baseline measures taken during the experimental session.

All subjects were required to wear dark adaption goggles 20 minutes prior to testing. Those subjects under the smoking treatment were required to wear goggles while smoking their test session cigarette.

The basic format of the experimental sessions for both tasks was the same. Basically, a 10 minute baseline period was established to account for individual fluctuations across sessions. A second 10 minute period allowed subjects in the smoking treatment time to smoke their test session cigarette. The final 40 minutes were used to measure the effects of treatment. The cigarettes used were obtained from the Kentucky Tobacco and Health Research Institute and contained 2.5 mg. nicotine and 30 mg. of tar. The order of treatment presentation was counterbalanced across subjects.

Data Analysis

Movement Detection: As in the first study, the movement detection task was designed to tap both the ability to detect and respond to trials in which the target moved and those in which it did not. Unlike the first study, however, scores were expressed in terms of deviations from pretreatment baseline estimates made for each session.

The smoker-smoker deprived comparisons for speed zero were made using a two-factor (smoking treatment and blocks) repeated measures analysis of variance for each of the variables (hit rate, decision latency, and confidence level). Each subject appeared under both smoking treatments and all eight blocks. For the data involving target movement, three-factor (smoking treatment, speeds and blocks) analyses were performed for each variable. Again, each subject appeared under all factor levels.

Comparisons for smoker deprived and nonsmoking subjects for speed zero were performed using a profile analysis for each variable. Differences were taken over blocks yielding tests of smoking treatment-blocks interaction, smoking treatment effects, and blocks effects respectively. For trials in which the target moved, a mixed model analysis of variance was used with one between (smoking treatment) and two within subjects factors (speeds and blocks). Since several interactions were found to be significant in these analyses further tests were performed. Note should be taken, however, that for tests of simple effects of interaction involving between and within subjects factors, the MS (w.cell) used to compute the F ratio represents a pooling of heterogeneous sources of variance. The result is an F ratio that will, in general, not be distributed as F. An F distribution can be approximated, however, by using an F distributed as p-1 and _f_, where _f_ represents the Satterthwaite _f_. Tests based on the adjusted degrees of freedom although not exact, will result in better estimates of the significance of an effect being tested. Details for the computation of _f_ are available in Winer (1971).

Velocity Estimation: The analysis objective in the velocity estimation task was to determine smoking treatment effects over a series of four blocks as measured by a subject's ability to make time of arrival estimates. As in the first study, measures of constant and absolute error were taken for each trial; however, for the purposes of this study, scores were expressed in terms of deviations from pretreatment baseline estimates.

For smoker-smoker deprived comparisons, a three-factor repeated measures analysis of variance was used with subjects appearing under all levels of smoking treatment, velocity, and blocks. For smoker deprived-nonsmoking comparisons, a mixed model analysis of variance was used with smoking treatment between subjects factor and velocity and blocks within subjects.

RESULTS

Movement Detection

As in the first study, significant hit rate differences between smoker and smoker deprived subjects for speed zero were found (Table 3). The baseline averages for the two treatments were 85% correct for smokers and 90% correct for deprived smokers. In post-treatment performance over the eight blocks of trials, smokers averaged 7% better than baseline whereas, deprived smokers averaged 12% under baseline. Again, smoking subjects were better able to detect non-movement of the target. The smoking treatment-blocks interaction for confidence level at speed zero was also revealed to be significant. These results are also shown in Table 3 and a plot of deviations from baseline versus blocks is shown in Figure 4. In the test of simple main effects for smoking treatment at levels of blocks, significant effects were found for blocks 2 and 7 (Table 4). The baseline confidence level means for smokers and deprived smokers were 3.30 and 3.25 respectively. For block 2, smokers averaged 8% below baseline and deprived smokers averaged 6.5% above. By block 7, however, smokers averaged 11% above baseline and deprived smokers averaged 6.5% below baseline indicating increasing confidence for smokers over blocks and decreasing confidence for deprived smokers.

The results of the analyses for the moving target trials for hit rate, decision latency, and confidence level are shown in Tables 10-12 (Appendix). Across the three variables, none of the interactions with smoking treatment were significant and none of the smoking treatment main effects were found to be significant.

The results of the profile comparisons for smoker deprived and nonsmoking subjects for speed zero are shown in Tables 13-15 (Appendix) and plots for each of the variables over blocks are shown in Figure 5. None of the smoking treatment-blocks interactions or tests of smoking treatment effect were found to be significant.

The data for trials involving target movement comparing smoker deprived and nonsmoking subjects revealed first order interactions of smoking treatment with speeds and smoking treatment with blocks to be significant for the hit rate measure (Table 5). The plots of these effects are shown in Figure 6. The tests of simple main effects of smoking treatment at levels of speed were all found to be nonsignificant (Table 6). The tests of simple effects for smoking treatment at levels of blocks, however, revealed a significant smoking effect for the first block of trials (Table 6). For this block, nonsmokers averaged 9% above baseline and deprived smokers 11% below. In the analysis of confidence level, a second significant smoking treatment-blocks interaction was found. These results are shown in Table 7 and plotted in Figure 7. In the test of simple main effects for this interaction (Table 8), significant treatment effects were found for blocks 6 and 7. The general trends of the data indicate a decrease in confidence across blocks for the nonsmokers and steady or increased confidence for the

Table 3

MOVEMENT DETECTION TASK
SMOKER VS. SMOKER DEPRIVED SPEED ZERO

	SS	df	MS	F	p >	p <
A		1				
Hit Rate	10.3711		10.3711	9.561	0.012	
Dec. Lat.	0.5820		0.5820	2.516	0.144	
Con. Lev.	0.1625		0.1625	0.511	0.502	
B		7				
Hit Rate	5.0190		0.7170	2.359	0.033	0.157
Dec. Lat.	0.8970		0.1281	0.930	0.509	
Con. Lev.	3.3869		0.4838	2.109	0.055	
AB		7				
Hit Rate	2.1022		0.3003	1.167	0.334	
Dec. Lat.	0.7522		0.1075	0.849	0.552	
Con. Lev.	3.6409		0.5201	2.793	0.014	0.126
S		9				
Hit Rate	27.2385		3.0265			
Dec. Lat.	22.3324		2.4814			
Con. Lev.	10.2856		1.1428			
AS		9				
Hit Rate	9.7619		1.0847			
Dec. Lat.	2.0820		0.2313			
Con. Lev.	2.8605		0.3178			
BS		63				
Hit Rate	19.1440		0.3039			
Dec. Lat.	8.6777		0.1377			
Con. Lev.	14.4499		0.2294			
ABS		63				
Hit Rate	16.2095		0.2573			
Dec. Lat.	7.9756		0.1266			
Con. Lev.	11.7309		0.1862			

A = Smoking Treatment
B = Blocks
S = Subjects

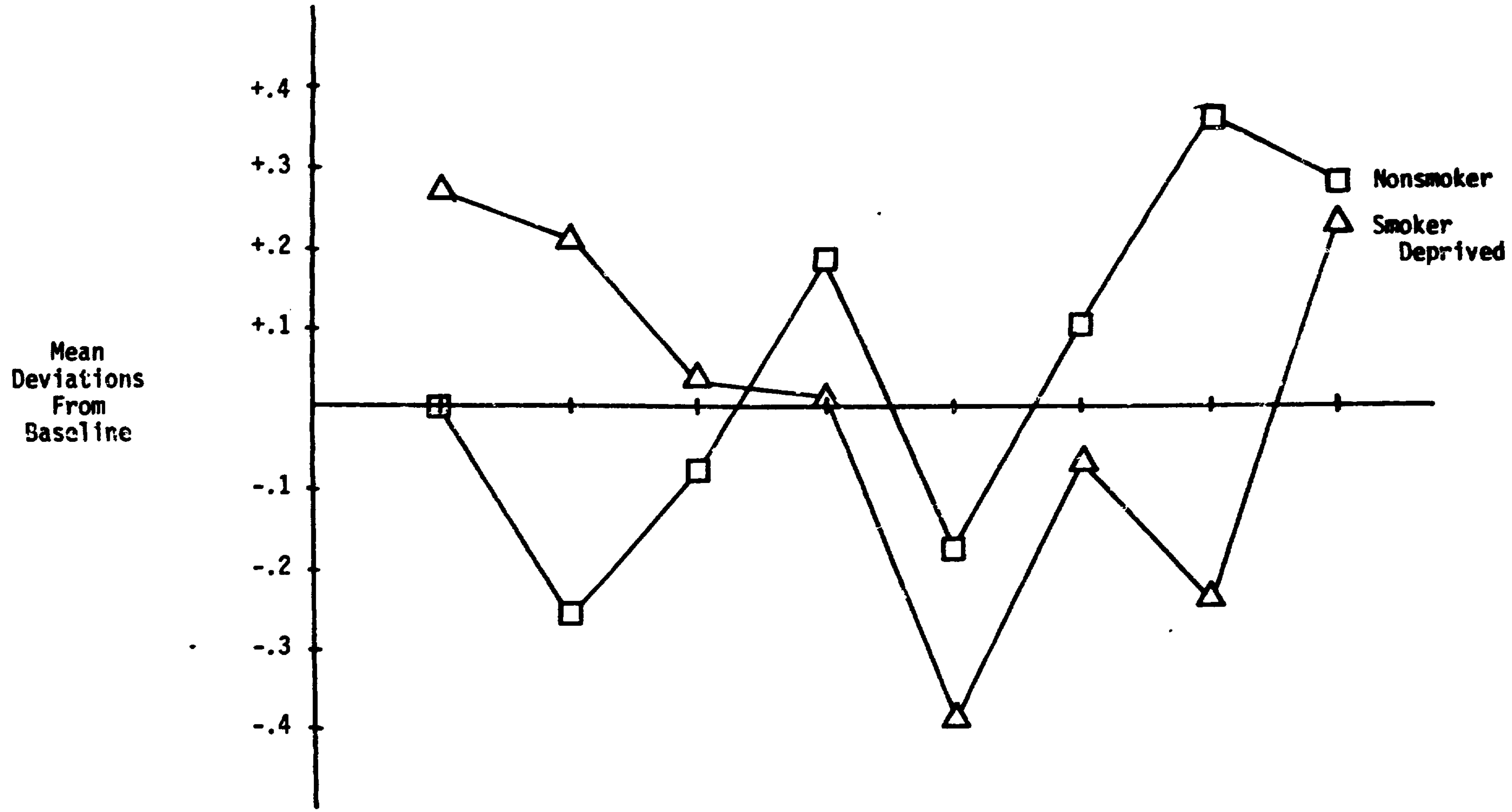


Figure 4

SMOKER VS. SMOKER DEPRIVED SPEED Ø CONFIDENCE LEVEL

Table 4

MOVEMENT DETECTION TASK TEST OF SIMPLE MAIN EFFECTS OF A AT B(X) SMOKER VS. SMOKER DEPRIVED CONFIDENCE LEVEL

	SS	df	MS	F	p >	p <
A	0.1625	1	0.1625			
A at B1	0.5773	1	0.5773	3.100	0.080	
A at B2	1.4448	1	1.4448	7.758	0.007	
A at B3	0.0215	1	0.0215	0.115	0.735	
A at B4	0.0768	1	0.0768	0.412	0.530	
A at B5	0.1273	1	0.1273	0.683	0.583	
A at B6	0.0768	1	0.0768	0.412	0.530	
A at B7	1.4581	1	1.4581	7.830	0.007	
A at B8	0.0213	1	0.0213	0.114	0.735	
AB	3.6409	7	0.5201			
ABS	11.7309	63	0.1862			

A = Smoking Treatment
B = Blocks
S = Subjects

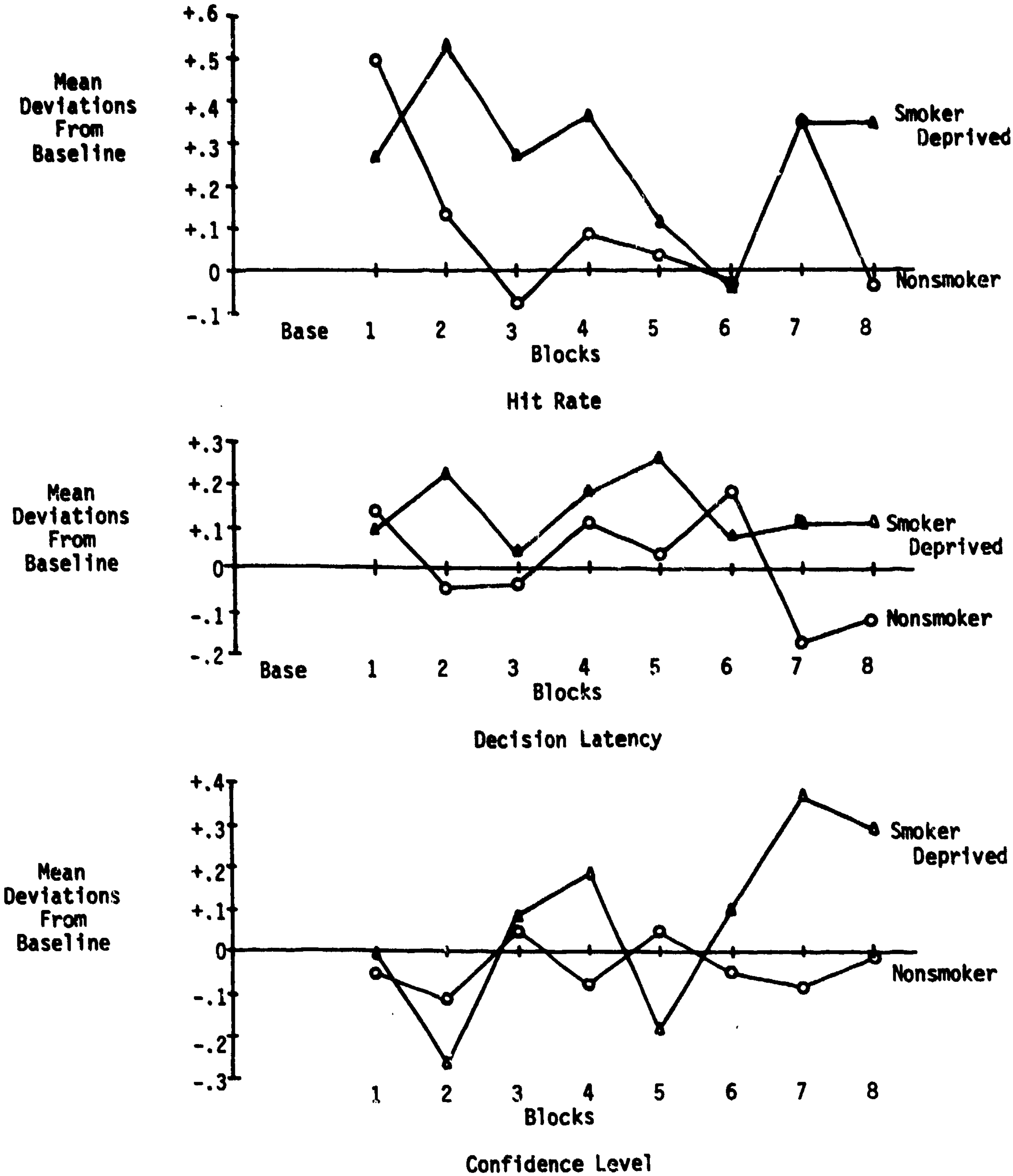


Figure 5

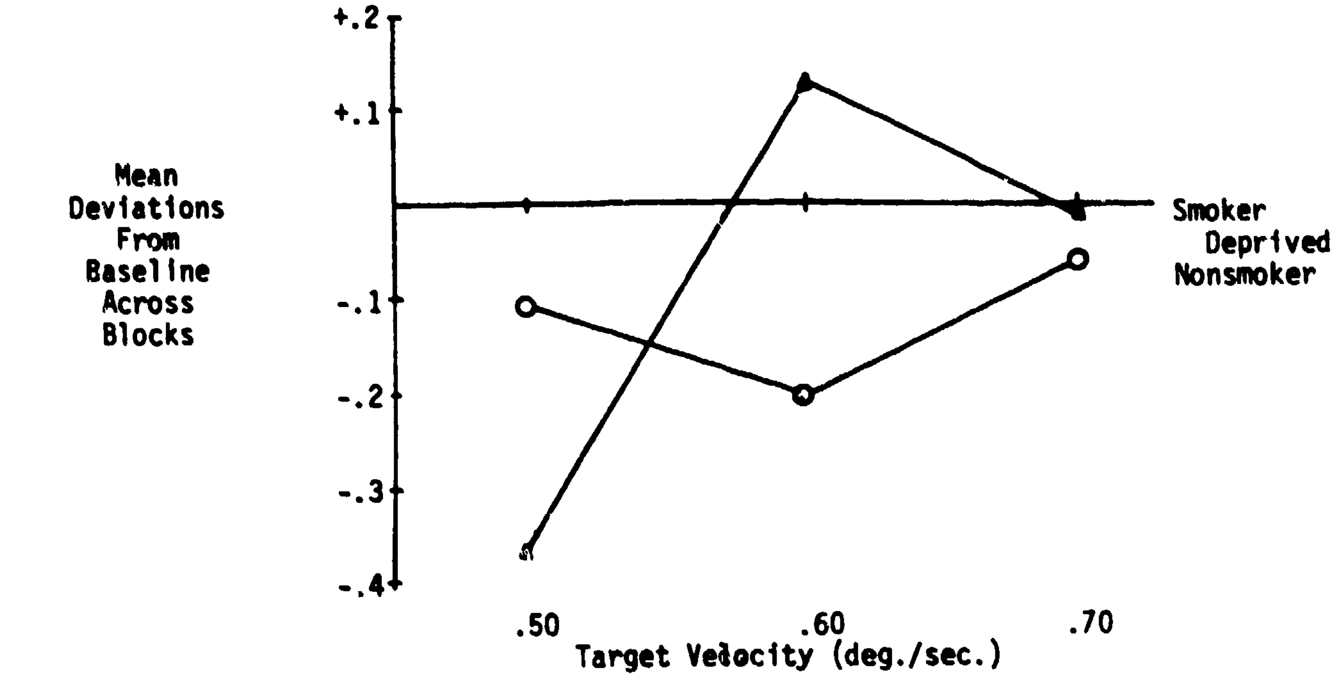
SMOKER DEPRIVED VS. NONSMOKER PROFILES FOR MOVEMENT DETECTION

Table 5

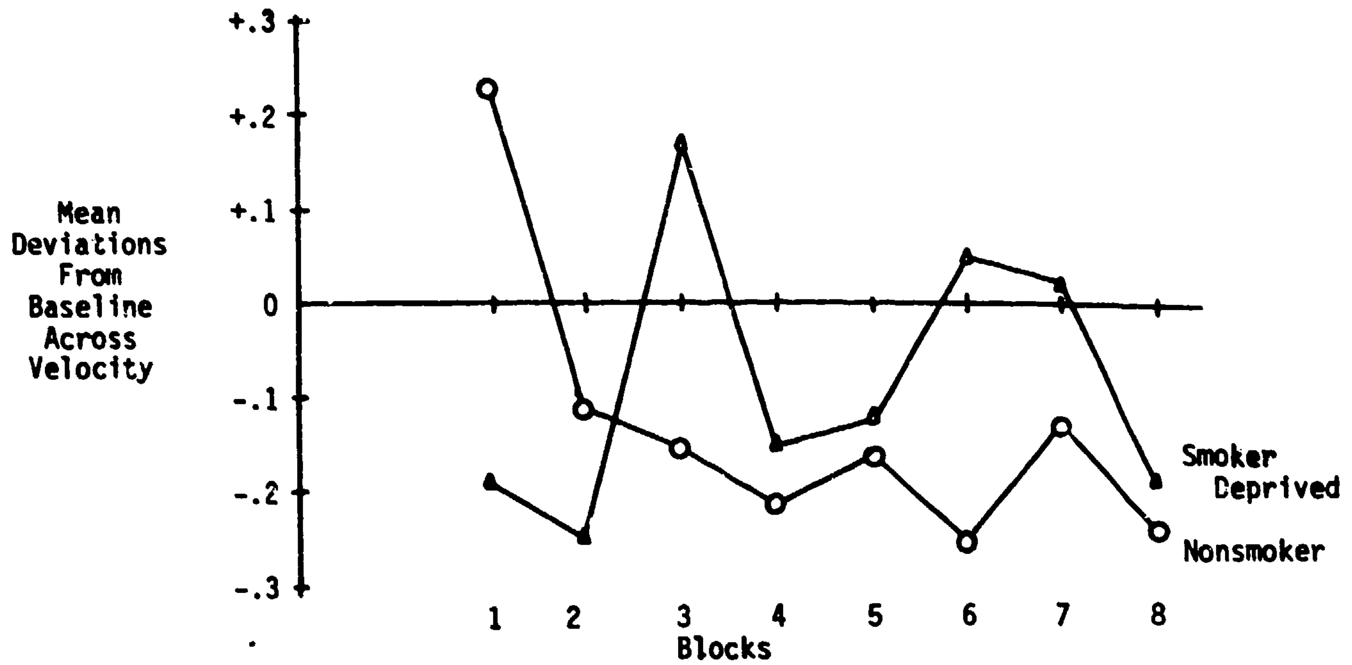
MOVEMENT DETECTION TASK
SMOKER DEPRIVED VS. NONSMOKER SPEEDS (50, 60, 70) HIT RATE

	SS	df	MS	F	p >	p <
BETWN S	54.8469	19				
A	0.2726	1	0.2726	0.089	0.765	
SUB W.G	54.5743	18	3.0319			
WITHN S	176.5250	460				
B	4.5904	2	2.2952	2.888	0.067	
AB	6.5593	2	3.2797	4.126	0.024	0.055
BX SW.G	28.6149	36	0.7949			
C	3.3533	7	0.4791	1.714	0.111	
AC	6.3199	7	0.9028	3.232	0.004	0.086
CX SW.G	35.2024	126	0.2794			
BC	9.2398	14	0.6599	2.114	0.012	0.160
ABC	3.9824	14	0.2844	0.911	0.547	
BCX SW.G	78.6628	252	0.3121			

A = Smoking Treatment
B = Speeds
C = Blocks



Smoking Treatment-Speed Interaction



Smoking Treatment-Blocks Interaction

Figure 6

SMOKER DEPRIVED VS. NONSMOKER FOR MOVEMENT DETECTION HIT RATE

Table 6

MOVEMENT DETECTION TASK TESTS OF SIMPLE MAIN EFFECTS OF
A AT B(X) AND A AT C(X) SMOKER DEPRIVED VS. NONSMOKER HIT RATE

	SS	df	MS	F(1, F)*	p
A at B1	2.4301	1	2.4301	1.5783	0.215
A at B2	4.2380	1	4.2380	2.7510	0.102
A at B3	0.1637	1	0.1637	0.1062	0.745
W. Cell	83.1893	54	1.5405		

A = Smoking Treatment
B = Speeds

	SS	df	MS	F(1, F)**	p
A at C1	2.7867	1	2.7867	4.4701	0.037
A at C2	0.2839	1	0.2889	0.4634	0.506
A at C3	1.5512	1	1.5512	2.4882	0.118
A at C4	0.0560	1	0.0560	0.0899	0.763
A at C5	0.0285	1	0.0285	0.0458	0.826
A at C6	1.4481	1	1.4481	2.3229	0.131
A at C7	0.4052	1	0.4052	0.6503	0.570
A at C8	0.0360	1	0.0360	0.0578	0.806
W. Cell	89.7867	144	0.6234		

A = Smoking Treatment
C = Blocks

* Satterthwaite F = 36.77 = 37
** Satterthwaite F = 45.97 = 46

Table 7

MOVEMENT DETECTION TASK SMOKER DEPRIVED VS. NONSMOKER
SPEEDS (50, 60, 70) CONFIDENCE LEVEL

	SS	df	MS	F	p >	p <
BETWN S	40.8953	19				
A	4.7581	1	4.7581	2.370	0.138	
SUB W.G	36.1372	18	2.0076			
WITHN S	128.3650	460				
B	3.5264	2	1.7632	2.891	0.066	
AB	1.2159	2	0.6080	0.997	0.619	
BX SW.G	21.9540	36	0.6098			
C	4.3232	7	0.6176	1.921	0.071	
AC	6.0551	7	0.8650	2.691	0.012	0.115
CX SW.G	40.4967	126	0.3214			
BC	1.9205	14	0.1372	0.733	0.741	
ABC	1.7129	14	0.1223	0.653	0.818	
BCX SW.G	47.1601	252	0.1871			

A = Smoking Treatment
B = Speeds
C = Blocks

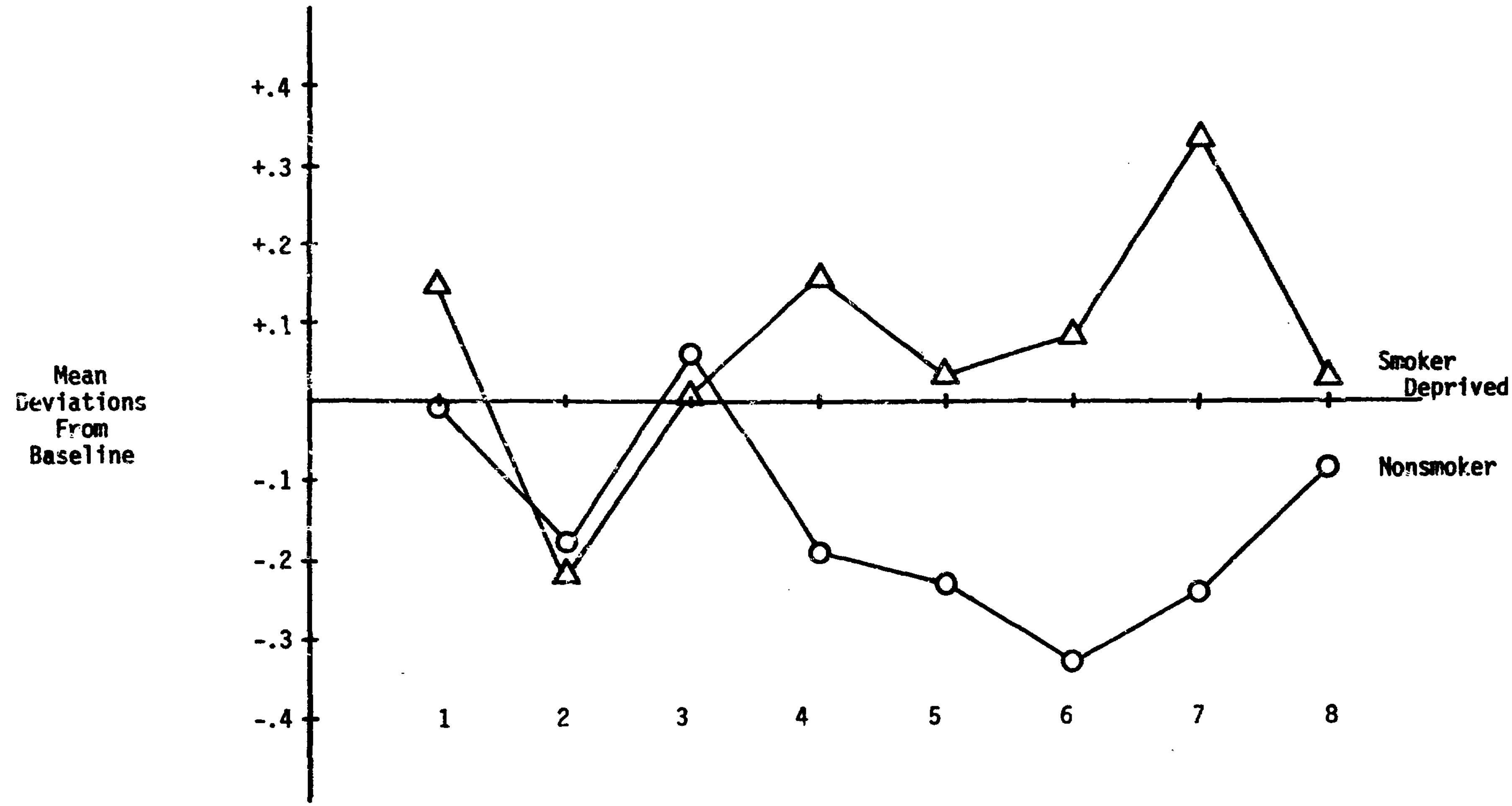


Figure 7

SMOKER-DEPRIVED VS. NONSMOKER
SPEEDS 50-70
CONFIDENCE LEVEL

Table 8

MOVEMENT DETECTION TASK TESTS OF SIMPLE MAIN EFFECTS OF A AT C(X) SMOKER DEPRIVED VS. NONSMOKER CONFIDENCE LEVEL

	SS	df	MS	F(1, F)*	p
A at C1	0.3375	1	0.3375	0.634	0.566
A at C2	0.0282	1	0.0282	0.052	0.813
A at C3	0.0482	1	0.0482	0.095	0.762
A at C4	1.8375	1	1.8375	3.452	0.064
A at C5	1.0402	1	1.0402	1.954	0.163
A at C6	2.6000	1	2.6000	4.885	0.029
A at C7	4.8735	1	4.8735	9.157	0.004
A at C8	0.0482	1	0.0482	0.090	0.762
W. Cell	76.6339	144	0.5322		

A = Smoking Treatment
C = Blocks

* Satterthwaire F = 68.63 = 69

deprived treatment. For block 6, the deprived smokers averaged 3% above baseline and the nonsmokers averaged 9% below. During block 7, smoker deprived subjects rose to 10% above baseline and nonsmokers averaged 6% below. For the decision latency measure, all tests of interactions and main effects were found to be nonsignificant (Table 16, Appendix).

Velocity Estimation

The comparisons for smokers and deprived smokers for absolute error show a significant interaction for smoking treatment with blocks (Table 9). The tests of simple effects revealed significant smoking treatment effects for blocks 2 and 4 (Table 10). The plot of these effects (Figure 8), shows a decrease in error from baseline for smokers and relatively constant block-baseline differences for deprived smokers. The baseline means for the two treatments were 4.1 degrees error for deprived smokers and 4.2 degrees for smokers. The mean deviations for smokers during blocks 2 and 4 were -10% and -32% respectively. For the deprived treatment, means of -31% and -14% were observed.

The tests of smoking treatment interactions and main effects for smokers and deprived smokers for constant error; and the comparisons of nonsmokers and deprived smokers for both constant and absolute error were all found to be nonsignificant. The results of these analyses are displayed in Tables 17-19 (Appendix).

Table 9

VELOCITY ESTIMATION TASK
SMOKER VS. SMOKER DEPRIVED ABSOLUTE ERROR

	SS	df	MS	F	p >	p <
A	0.6678	1	0.6678	0.350	0.849	
B	10.3858	2	5.1929	1.549	0.239	
AB	6.2202	2	3.1101	0.959	0.596	
C	7.4480	3	2.4826	2.432	0.086	
AC	21.6942	3	7.2314	5.442	0.005	0.043
BC	0.6526	6	0.1088	0.183	0.979	
ABC	3.8311	6	0.6385	1.632	0.156	
S	94.3690	9	10.4854			
AS	171.7650	9	19.0850			
BS	60.3313	18	3.3517			
ABS	58.3733	18	3.2430			
CS	27.5569	27	1.0206			
ACS	35.8786	27	1.3288			
BCS	32.0110	54	0.5928			
ABCS	21.1168	54	0.3911			

A = Smoking Treatment
B = Velocity
C = Blocks
S = Subjects

Table 10

VELOCITY ESTIMATION TASK SMOKER VS. SMOKER DEPRIVED TEST
OF SIMPLE MAIN EFFECTS OF A AT C(X) ABSOLUTE ERROR

	SS	df	MS	F	p >	p <
A at C1	2.9298	1	2.9298	2.205	0.146	
A at C2	8.3700	1	8.3700	6.298	0.017	
A at C3	3.3020	1	3.3020	2.484	0.123	
A at C4	7.7604	1	7.7604	5.840	0.021	
ACS	35.8786	27	1.3288			

A = Smoking Treatment
C = Blocks

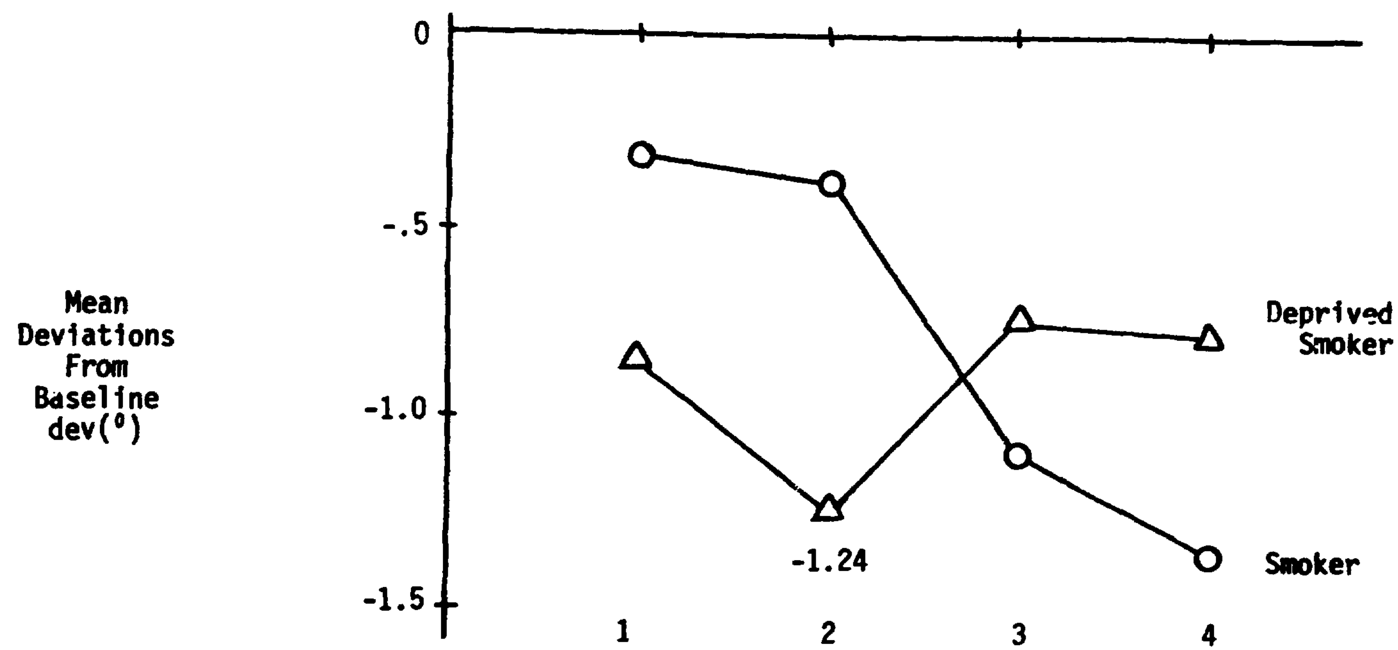


Figure 8

SMOKER VS. SMOKER DEPRIVED VELOCITY ESTIMATION
ABSOLUTE ERROR

DISCUSSION

The purpose of this investigation was to isolate two specific aspects of the relationship between smoking and the detection of target movement in the visual periphery. In the first study, the relationship of interest was the effect of nicotine dosage level on performance. In the second study, an investigation was made of the onset, duration, and decay of smoking effects. Previous research investigating the effects of smoking on static peripheral acuity (Johnston, 1965b; Krippner and Heimstra, 1969), indicated a narrowing of the temporal field shortly after smoking. In an investigation using dynamic peripheral targets, Scoughton and Heimstra (1973) found a significant decrement in a smoking subject's ability to both make near-threshold judgements of motion in his periphery, and estimate the time of arrival of a hidden moving target with a stationary target. The results of the present investigation also indicate an effect of smoking on peripheral visual performance. However, the details of this relationship appear to be more complex than previous research has indicated.

As pointed out in the introduction to the first study, several investigators have reported significant nicotine dosage effects on visual performance. In the current investigation, it was found that the smoker-high nicotine subjects were significantly better able to detect non-movement of the target than the low nicotine and deprived subjects. In terms of percentage of correct rejections, the high nicotine treatment scored 80% correct while low and deprived treatments scored 65% and 61% respectively. The fact that nonsmokers were not found to be significantly different from deprived smokers (63% correct) would lend support to the hypothesis that the effect can be attributed to the actual intake of nicotine rather than possible nicotine deprivation effects that could have occurred in the deprived and low nicotine treatments. The physiological mechanisms responsible for this result can only be speculated. Hall et. al. (1973) studying tobacco and evoked potential found a decrease of the amplitude envelope accompanying withdrawal and an increase with resumption of smoking in a task involving the perception of four intensities of flashing lights (15 sec. flashes at 9,34,138 and 420 lux). This result was found by the investigators to be consistant with the notion that smoking increases arousal. Analysis of changes in the amplitude of the IV-V complex of the evoked potential showed significant increases upon resumption of smoking for the 9 and 34 lux stimuli but not for the 138 and 420 lux presentations. On the basis of this result, the authors suggested that possibly smoking selectively enhances the perception of weak stimuli. Although extremely tenuous, because of the differences in the tasks being performed, a selective enhancement hypothesis for peripheral movement detection would explain significant differences for zero movement in the face of nonsignificance for the four movement speeds, if one defines the strength of a moving stimulus in terms of the amount of change in retinal area scanned per unit time.

On a more practical level, however, considering the entire set of results for the first study, a definitive effect of nicotine dosage on the tasks performed was not found. It has been reported by Ashton et. al. (1970), studying the puffing frequency and nicotine intake in cigarette smokers, that smokers of low nicotine cigarettes take more frequent puffs than when smoking higher nicotine cigarettes. These researchers found their results consistant with the hypothesis that there exists an "optimum" nicotine dose for a given activity and that smokers unconsciously modify their smoking patterns in an attempt to procure this dosage. This would explain the lack of significance found for the tasks in terms of high and low nicotine comparisons. However, the nonsignificance of comparisons of these treatments in conjunction with the deprived treatment cannot be explained in the fact of previously obtained significance for similar tasks (Scoughton and Heimstra, 1973).

The second study was designed to determine the time/response characteristics of smoking and smoking deprived subjects by analyzing their performance over a series of blocks. For this investigation, particular emphasis was placed not only on the smoking treatment main effects, but also possible treatment-blocks interactions. As was the case in the first study, subjects appearing under the smoking treatment were better able to detect non-movement of the target than when appearing under the smoking deprived treatment. This result lends further support to the notion that perhaps some form of selective enhancement is taking place. Another interesting smoking treatment effect found for speed zero was the smoking treatment-blocks interaction for confidence level. The general trend of the deprived group was a loss in confidence for the first five blocks of trials and an increase for the the last three. Roughly, the smoking group increased in confidence across all eight blocks. These treatment contingent trends, however, seemed to be relatively independent of actual performance since smokers maintained a superior mean hit rate across blocks. Heimstra (1975) in a review of the effects of smoking on mood change has reported that smoking tends to reduce fluctuation or change in mood. In studies of smoking, smoking deprived, and nonsmoking subjects for a variety of tasks in which pre and post mood factor scores were obtained, smokers typically showed fewer changes. Also, the mood factor scores obtained were typically not found to be correlated with performance. These results bear some resemblance to the confidence level data in the sense that deprived smokers showed an initial loss in confidence with a return to baseline during the last three blocks of trials, whereas smokers tended to show a more consistent rise in confidence across blocks. Another resemblance is the fact that level of confidence did not seem to be related to hit rate performance.

The smoker-smoker deprived comparisons for the velocity estimation task showed a significant treatment-blocks interaction for the absolute error measure. The baseline deviation for the deprived group appeared to stabilize at about -.75 degrees which corresponded to a mean error of 3.3 degrees. The smokers, however, showed an increase in accuracy for each succeeding block of trials; being inferior to the deprived smokers for the first two blocks of trials, and superior for the third and fourth blocks. The largest increase was found between the second and third blocks. The inferior performance for the first 20 minutes of trials is similar to the result obtained in a previous investigation involving a study of the relationships between smoking and performance of a velocity estimation task (Scoughton and Heimstra, 1973). In this investigation, it was found that smoking subjects, performing under conditions of low illumination, were inferior to deprived smokers in their ability to make velocity estimates. The task session length used for this investigation was 20 minutes. The results of the current investigation not only support those results obtained previously, but give an indication of what the duration of this effect might be. The interpretation given these data is that after smoking there is an almost immediate impairment in the ability to make peripheral estimates of closure which begins to decrease after about 20 minutes. After this initial period, there exists the possibility of a period of enhanced performance which, although not determined due to session length, is assumed to taper off.

Although not the only significant smoking effect found in this investigation, the most important finding from an applied standpoint is the impairment/enhancement effect found in the velocity estimation task. Several critical questions remain to be resolved concerning this task. First, a determination should be made concerning whether the enhancement phase really exists or whether it was merely an artifact in the data. If it does exist, a determination should be made concerning its duration and decay. Second and probably more important, is whether the fact that targets were viewed peripherally is important or even relevant to an explanation of the phenomenon. In other studies concerned with the perception of velocity and prediction of velocity and prediction of motion (Dembitz, 1927; Johansson, 1950; Gerhard, 1959; Ellingstad, 1967; and Ellingstad and Heimstra, 1969) the critical factor which determined accuracy of judgements was shown to depend upon the subject's ability to estimate the temporal duration of stimulus exposure and use that as a metric to calculate time to target. This is precisely what subjects in this investigation appeared to do. The exposure distance used in the second study was 8 degrees and the concealment distance was 12 degrees. With the observed mean baseline error of 4 degrees (4.06 deg. for smoker deprived and 4.19 deg. for smokers), the indication is that subjects simply estimated the time of exposure, waited for that period of time, and then responded. If this is the case, then significant smoking effects would indicate an effect of smoking on the ability to make time estimates. This would mean the involvement of higher order information processing systems rather than just simple peripheral sensory effects. The practical implications of such an effect could be extrapolated to a wide variety of dynamic systems. For instance, pilots of both F/W and R/W aircraft are constantly making judgements of closure between their vehicle and approaching aircraft, obstacles during low altitude flight envelopes, and the ground while landing. A distorted perception of time intervals would affect all of these critical functions.

In general, it can be concluded that smoking affects several critical visual and higher order processing functions. While the data failed to reveal the precise relationships between nicotine dosage and performance, several time contingent smoking effects were found in the determination of time/response characteristics. It is suggested that further studies be conducted to expand the area of knowledge of such a common habit.

APPENDIX A

Table 1

MOVEMENT DETECTION TASK SMOKERS (HI, LO, DEP)
SPEEDS (50, 55, 60, 65)

	SS	df	MS	F	p >	p <
A		2				
Hit Rate	0.32252		0.16126	0.551	0.588	
Dec. Lat.	0.44842		0.22421	0.583	0.571	
Con. Lev.	0.29018		0.14509	0.179	0.838	
B		3				
Hit Rate	2.85864		0.95288	15.142	0.000	0.003
Dec. Lat.	0.88857		0.29619	7.695	0.001	0.017
Con. Lev.	2.16417		0.72139	5.468	0.004	0.038
AB		6				
Hit Rate	0.33072		0.05512	1.041	0.408	
Dec. Lat.	0.20784		0.03464	0.887	0.511	
Con. Lev.	1.45452		0.24242	2.066	0.069	
S		11				
Hit Rate	5.22258		0.47478			
Dec. Lat.	18.30301		1.66391			
Con. Lev.	31.97557		2.90687			
AS		22				
Hit Rate	6.43698		0.29259			
Dec. Lat.	8.46010		0.38455			
Con. Lev.	17.78502		0.80841			
BS		33				
Hit Rate	2.07669		0.06293			
Dec. Lat.	1.27017		0.03849			
Con. Lev.	4.35369		0.13193			
ABS		66				
Hit Rate	3.49602		0.05297			
Dec. Lat.	2.57664		0.03904			
Con. Lev.	7.74510		0.11735			

A = Smoking Treatment
B = Speeds

Table 2

MOVEMENT DETECTION TASK
SMOKER DEPRIVED VS. NONSMOKER SPEED ZERO

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
3	18	0.425	0.740	0.93381

Univariate Tests

	SS	df	MS	F	p
Hit Rate	0.00745	1	0.00745	0.033	0.853
Dec. Lat.	0.34885	1	0.34885	1.103	0.307
Con. Lev.	0.74693	1	0.74693	1.000	0.331

Table 3

PROFILE ANALYSIS FOR HIT RATE
SMOKER DEPRIVED VS. NONSMOKER SPEEDS (50, 55, 60, 65)

Hypothesis One: Parallelism (Interaction)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
3	18	0.947	0.560	0.86360

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
.50-.55	0.14001	20	0.00186	1	0.013	0.905
.55-.60	0.20306	20	0.20202	1	0.995	0.668
.60-.65	0.10347	20	0.27528	1	2.660	0.115

Hypothesis Two: Levels (Test of Sums Across Profile)

	MS(Err)	df	MS(Hyp)	df	F	p
Groups	1.41350	20	0.19424	1	0.137	0.715

Hypothesis Three: Flatness (Slope of Pooled Profile)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
3	18	8.430	0.001	0.41579

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
.50-.55	0.14001	20	0.45821	1	3.273	0.082
.55-.60	0.20306	20	0.45763	1	2.254	0.146
.60-.65	0.10347	20	0.38412	1	3.712	0.065

Table 4

PROFILE ANALYSIS FOR DECISION LATENCY
SMOKER DEPRIVED VS. NONSMOKER SPEEDS (50, 55, 60, 65)

Hypothesis One: Parallelism (Interaction)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
3	18	0.724	0.553	0.89230

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
.50-.55	0.07534	20	0.01168	1	0.155	0.700
.55-.60	0.07485	20	0.16149	1	2.157	0.154
.60-.65	0.05650	20	0.00020	1	0.004	0.952

Hypothesis Two: Level (Test of Sums Across Profile)

	MS(Err)	df	MS(Hyp)	df	F	p
Groups	3.91902	28	4.98170	1	1.271	0.272

Hypothesis Three: Flatness (Slope of Pooled Profile)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
3	18	3.777	0.029	0.61370

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
.50-.55	0.07534	20	0.29026	1	3.853	0.061
.55-.60	0.07485	20	0.00197	1	0.026	0.867
.60-.65	0.05650	20	0.39022	1	6.906	0.015

Table 5

PROFILE ANALYSIS FOR CONFIDENCE LEVEL
SMOKER DEPRIVED VS. NONSMOKER SPEEDS (50, 55, 60, 65)

Hypothesis One: Parallelsim (Interaction)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
3	18	2.228	0.119	0.72936

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
.50-.55	0.25454	20	0.00340	1	0.013	0.905
.55-.60	0.25884	20	1.05648	1	4.082	0.054
.60-.65	0.24186	20	0.17111	1	0.707	0.585

Hypothesis Two: Level (Test of Sums Across Profile)

	MS(Err)	df	MS(Hyp)	df	F	p
Groups	7.41819	20	0.00479	1	0.001	0.978

Hypothesis Three: Flatness (Slope of Pooled Profile)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
3	18	3.693	0.031	0.61902

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
.50-.55	0.25454	20	0.40800	1	1.603	0.218
.55-.60	0.25884	20	0.04545	1	0.176	0.682
.60-.65	0.24186	20	1.29471	1	5.353	0.030

Table 6

VELOCITY ESTIMATION TASK SMOKERS (HI, LO, DEP)
CONSTANT ERROR

	SS	df	MS	F	p >	p <
A	3.07251	2	1.53626	0.135	0.874	
B	96.31420	2	48.15710	15.514	0.000	0.003
AB	0.53080	4	0.13721	0.136	0.967	
C	3.51579	2	1.75790	2.069	0.149	
AC	3.95831	4	0.98958	0.938	0.547	
BC	4.78505	4	1.19626	1.386	0.254	
ABC	4.23969	8	0.52996	0.673	0.715	
S	723.68900	11	65.78990			
AS	251.26800	22	11.42130			
BS	68.29050	22	3.10411			
ABS	42.99720	44	0.97721			
CS	18.69090	22	0.84959			
ACS	46.44630	44	1.05560			
BCS	37.98060	44	0.86320			
ABCS	69.32150	88	0.78774			

A = Smoking Treatment
B = Velocity
C = Distance
S = Subjects

Table 7

VELOCITY ESTIMATION TASK SMOKERS (HI, LO, DEP)
ABSOLUTE ERROR

	SS	df	MS	F	p >	p >
A	0.77405	2	0.38703	0.041	0.960	
B	89.87870	2	44.93940	20.233	0.000	0.001
AB	0.23362	4	0.05841	0.065	0.991	
C	1.65980	2	0.82990	0.904	0.578	
AC	3.45025	4	0.86256	0.986	0.574	
BC	2.29740	4	0.57435	0.891	0.521	
ABC	8.14267	8	1.01783	2.067	0.047	0.176
S	562.46700	11	51.13333			
AS	206.49500	22	9.38611			
BS	48.86450	22	2.22111			
ABS	39.54970	44	0.89886			
CS	20.19750	22	0.91807			
ACS	38.47820	44	0.87451			
BCS	28.37500	44	0.64489			
ABCS	43.32290	88	0.49231			

A = Smoking Treatment
B = Velocity
C = Distance
S = Subjects

Table 8

VELOCITY ESTIMATION TASK UNWEIGHTED MEANS ANALYSIS
SMOKER DEPRIVED VS. NONSMOKER CONSTANT ERROR

	SS	df	MS	F	p >	p <
BETWN S	430.17300	21				
A	5.38364	1	5.38362	0.253	0.637	
SUB W.G	424.79152	20	21.23962			
WITHN S	499.66421	176				
B	85.78420	2	42.89211	27.523	0.000	0.000
AB	4.84317	2	2.42155	1.552	0.222	
Bx SW.G	62.33660	40	1.55841			
C	3.84214	2	1.92110	1.190	0.315	
AC	7.74610	2	3.87318	2.399	0.102	
CX SW.G	64.57011	40	1.61425			
BC	3.14297	4	0.78573	0.238	0.916	
ABC	0.28945	4	0.07244	0.021	0.998	
BCX SW.G	270.02950	80	3.37543			

A = Smoking Treatment
B = Velocity
C = Distance

Table 9

VELOCITY ESTIMATION TASK UNWEIGHTED MEANS ANALYSIS
SMOKER DEPRIVED VS. NONSMOKER ABSOLUTE ERROR

	SS	df	MS	F	p >	p <
BETWN S	354.84430	21				
A	9.87464	1	9.87466	0.572	0.536	
SUB W.G	344.98065	20	17.24907			
WITHN S	232.09742	176				
B	73.18823	2	36.59412	31.522	0.000	0.000
AB	2.99092	2	1.49552	1.288	0.287	
BX SW.G	46.38280	40	1.16093			
C	7.02337	2	3.51166	2.739	0.075	
AC	4.63665	2	2.31838	1.808	0.175	
CX SW.G	51.18370	40	1.28174			
BC	1.10594	4	0.27659	0.472	0.758	
ABC	0.87874	4	0.21977	0.375	0.827	
BCX SW.G	46.90264	80	0.58653			

A = Smoking Treatment
B = Velocity
C = Distance

Table 10

MOVEMENT DETECTION TASK
SMOKER VS. SMOKER DEPRIVED SPEEDS (50, 60, 70) HIT RATE

	SS	df	MS	F	p >	p <
A	0.0737	1	0.0737	0.019	0.887	
B	13.2096	2	6.6048	3.833	0.040	0.079
AB	2.2724	2	1.1362	0.912	0.578	
C	5.2425	7	0.7489	2.519	0.024	0.145
AC	3.5593	7	0.5085	1.825	0.097	
BC	9.0560	14	0.6469	2.191	0.011	0.171
ABC	1.8208	14	0.1301	0.387	0.976	
S	43.4425	9	4.8269			
AS	34.2553	9	3.8062			
BS	31.0116	18	1.7229			
ABS	22.4148	18	1.2453			
CS	18.7243	63	0.2972			
ACS	17.5448	63	0.2785			
BCS	37.1998	126	0.2952			
ABCS	42.2812	126	0.3356			

A = Smoking Treatment
B = Speeds
C = Blocks
S = Subjects

Table 11

MOVEMENT DETECTION TASK SMOKER VS. SMOKER DEPRIVED
SPEEDS (50, 60, 70) DECISION LATENCY

	SS	df	MS	F	p >	p <
A	0.4429	1	0.4429	0.217	0.655	
B	0.9997	2	0.4999	1.165	0.335	
AB	0.0215	2	0.0108	0.024	0.976	
C	0.8755	7	0.1251	0.592	0.761	
AC	1.9204	7	0.2743	0.824	0.572	
BC	1.3403	14	0.0957	1.057	0.402	
ABC	1.1247	14	0.0803	0.843	0.622	
S	72.8315	9	8.0924			
AS	18.3402	9	2.0378			
BS	7.7188	18	0.4288			
ABS	7.8089	18	0.4338			
CS	13.3088	63	0.2113			
ACS	20.9711	63	0.3329			
BCS	11.4043	126	0.0905			
ABCS	12.0054	126	0.0952			

A = Smoking Treatment
B = Speeds
C = Blocks
S = Subjects

Table 12

MOVEMENT DETECTION TASK SMOKER VS. SMOKER DEPRIVED
SPEEDS (50, 60, 70) CONFIDENCE LEVEL

	SS	df	MS	F	p >	p <
A	3.6908	1	3.6908	1.382	0.269	
B	0.4779	2	0.2389	0.319	0.734	
AB	7.3633	2	3.6817	2.768	0.088	
C	2.8953	7	0.4136	1.449	0.201	
AC	3.6616	7	0.5231	1.538	0.171	
BC	2.0077	14	0.1434	0.660	0.809	
ABC	2.7614	14	0.1972	0.742	0.729	
S	15.7839	9	1.7538			
AS	24.0247	9	2.6694			
BS	13.4602	18	0.7478			
ABS	23.9401	18	1.3300			
CS	17.9814	63	0.2854			
ACS	21.4291	63	0.3401			
BCS	27.3675	126	0.2172			
ABCS	33.4601	126	0.2656			

A = Smoking Treatment
B = Speeds
C = Blocks
S = Subjects

Table 13

PROFILE ANALYSIS FOR HIT RATE
SMOKER DEPRIVED VS. NONSMOKER SPEED ZERO

Hypothesis One: Parallelism (Interaction)

Multiavariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
7	12	0.786	0.613	0.68576

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
BLK 1-2	0.50852	18	1.94699	1	3.829	0.063
BLK 2-3	0.21131	18	0.01177	1	0.056	0.811
BLK 3-4	0.69680	18	0.03569	1	0.051	0.818
BLK 4-5	0.52077	18	0.17131	1	0.329	0.580
BLK 5-6	0.22126	18	0.03569	1	0.161	0.694
BLK 6-7	0.59543	18	0.00008	1	0.000	0.988
BLK 7-8	0.62642	18	0.76207	1	1.217	0.284

Hypothesis Two: Level (Test of Sums Across Profile)

MS(Err)	df	MS(Hyp)	df	F	p
21.0565	18	7.37628	1	0.350	0.568

Hypothesis Three: Flatness (Slope of Pooled Profile)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
7	12	2.923	0.049	0.36968

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
BLK 1-2	0.50852	18	0.04299	1	0.085	0.771
BLK 2-3	0.21131	18	1.20725	1	5.713	0.027
BLK 3-4	0.69680	18	0.36435	1	0.523	0.515
BLK 4-5	0.52077	18	0.39799	1	0.764	0.602
BLK 5-6	0.22126	18	0.34150	1	1.543	0.228
BLK 6-7	0.59543	18	3.20987	1	5.391	0.030
BLK 7-8	0.62642	18	0.76206	1	1.217	0.284

Table 14

PROFILE ANALYSIS FOR DECISION LATENCY
SMOKER DEPRIVED VS. NONSMOKER SPEED ZERO

Hypothesis One: Parallelism (Interaction)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
7	12	1.810	0.175	0.48645

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
BLK 1-2	0.37356	18	0.09799	1	0.262	0.620
BLK 2-3	0.36378	18	0.16200	1	0.445	0.519
BLK 3-4	0.12200	18	0.24200	1	1.984	0.173
BLK 4-5	0.40000	18	1.15200	1	2.880	0.104
BLK 5-6	0.23311	18	0.72200	1	3.097	0.092
BLK 6-7	0.22889	18	0.39200	1	1.713	0.205
BLK 7-8	0.21000	18	0.09799	1	0.467	0.510

Hypothesis Two: Level (Test of Sums Across Profile)

	MS(Err)	df	MS(Hyp)	df	F	p
Groups	5.47688	18	2.88800	1	0.527	0.517

Hypothesis Three: Flatness (Slope of Pooled Profile)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
7	12	1.678	0.205	0.50538

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
BLK 1-2	0.37356	18	0.33799	1	0.905	0.644
BLK 2-3	0.36378	18	1.25000	1	3.436	0.077
BLK 3-4	0.12200	18	0.00199	1	0.016	0.895
BLK 4-5	0.40000	18	0.28799	1	0.720	0.588
BLK 5-6	0.23311	18	0.16200	1	0.695	0.580
BLK 6-7	0.22889	18	0.28800	1	1.258	0.276
BLK 7-8	0.21000	18	0.00200	1	0.010	0.920

Table 15

PROFILE ANALYSIS FOR CONFIDENCE LEVEL SMOKER DEPRIVED VS. NONSMOKER SPEED ZERO

Hypothesis One: Parallelism (Interaction)

Multivariate Test

df(Hyp)	df(Err)	F	p	Wilks Lambda
7	12	2.074	0.128	0.45254

Individual Profile Segments

BLK 1-2	MS(Err)	df	MS(Hyp)	df	F	p
BLK 1-2	0.15805	18	0.52164	1	3.300	0.083
BLK 2-3	0.12236	18	0.19800	1	1.618	0.218
BLK 3-4	0.10042	18	0.00199	1	0.020	0.884
BLK 4-5	0.10513	18	0.12013	1	1.143	0.300
BLK 5-6	0.10206	18	0.50244	1	4.923	0.038
BLK 6-7	0.06161	18	0.78013	1	12.662	0.003
BLK 7-8	0.07509	18	0.15665	1	2.086	0.163

Hypothesis Two: Level (Test of Sums Across Profile)

	MS(Err)	df	MS(Hyp)	df	F	p
Groups	10.9548	18	3.95159	1	0.361	0.562

Hypothesis Three: Flatness (Slope of Pooled Profile)

Multivariate Test

df(hyp)	df(Err)	F	p	Wilks Lambda
7	12	2.481	0.080	0.40866

Individual Profile Segments

	MS(Err)	df	MS(Hyp)	df	F	p
BLK 1-2	0.15805	18	0.01300	1	0.082	0.774
BLK 2-3	0.12236	18	0.15665	1	1.280	0.272
BLK 3-4	0.10042	18	0.40328	1	4.016	0.058
BLK 4-5	0.10513	18	0.00005	1	0.000	0.982
BLK 5-6	0.10206	18	0.00180	1	0.018	0.891
BLK 6-7	0.06161	18	0.61600	1	9.999	0.005
BLK 7-8	0.07509	18	0.14965	1	1.993	0.172

Table 16

MOVEMENT DETECTION TASK SMOKER DEPRIVED VS. NONSMOKER
SPEEDS (50, 60, 70) DECISION LATENCY

	SS	df	MS	F	p >	p <
BETWN S	65.0198	19				
A	0.0079	1	0.0079	0.002	0.963	
SUB W.G	65.0119	18	3.6117			
WITHN S	1397.1900	460				
B	0.0883	2	0.0442	0.144	0.866	
AB	1.0759	2	0.5379	1.762	0.185	
BX SW.G	10.9935	36	0.3052			
C	1.1258	7	0.1608	0.578	0.774	
AC	0.3121	7	0.0446	0.160	0.991	
CX SW.G	35.0564	126	0.2782			
BC	1.0810	14	0.0772	0.014	0.999	
ABC	1.0539	14	0.0753	0.014	0.999	
BCX SWG	1346.4000	252	0.5342			

A = Smoking Treatment
B = Speeds
C = Blocks

Table 17

VELOCITY ESTIMATION TASK
SMOKER VS. SMOKER DEPRIVED CONSTANT ERROR

	SS	DF	MS	F	p >	p <
A	75.3423	1	75.3423	1.501	0.251	
B	3.0328	2	1.5164	0.427	0.663	
AB	3.5404	2	1.7702	0.347	0.716	
C	71.7417	3	23.9139	10.002	0.000	0.011
AC	10.9385	3	3.6462	1.257	0.309	
BC	6.6156	6	1.1026	1.549	0.180	
ABC	0.5259	6	0.0877	0.159	0.985	
S	125.4820	9	13.9425			
AS	451.7020	9	50.1891			
BS	63.8463	18	3.5470			
ABS	91.8003	18	5.1000			
CS	64.5490	27	2.3907			
ACS	87.4550	27	3.2391			
BCS	38.4291	54	0.7117			
ABCS	29.7357	54	0.5506			

A = Smoking Treatment
B = Velocity
C = Blocks
S = Subjects

Table 18

VELOCITY ESTIMATION TASK
SMOKER DEPRIVED VS. NONSMOKER CONSTANT ERROR

	SS	df	MS	F	p >	p <
BETWN S	1050.8900	19				
A	10.4951	1	10.4951	0.181	0.678	
SUB W.G	1040.4000	18	57.7998			
WITHN S	475.0260	220				
B	33.1805	2	16.5902	4.144	0.023	0.054
AB	16.0786	2	8.0393	2.008	0.147	
BX SW.G	144.1150	36	4.0031			
C	30.9908	3	10.3303	3.850	0.014	0.053
AC	5.3633	3	1.7877	0.666	0.580	
CX SW.G	144.8720	54	2.6828			
BC	6.1894	6	1.0315	1.317	0.255	
ABC	9.6944	6	1.6157	2.064	0.063	
BCX SW.G	84.5414	108	0.7827			

A = Smoking Treatment
B = Velocity
C = Blocks

Table 19

VELOCITY ESTIMATION TASK
SMOKER DEPRIVED VS. NONSMOKER ABSOLUTE ERRER

	SS	df	MS	F	p >	p <
BETWN S	435.7460	19				
A	66.3075	1	66.3075	3.230	0.085	
SUB W.G	369.4380	18	20.5243			
WITHN S	373.5920	220				
B	2.7663	2	1.3832	0.272	0.767	
AB	2.2822	2	1.1411	0.225	0.802	
BX SW.G	182.9440	36	5.0818			
C	12.6670	3	4.2223	2.451	0.072	
AC	12.3535	3	4.1178	2.390	0.078	
CX SW.G	93.0287	54	1.7228			
BC	3.5411	6	0.5902	1.027	0.412	
ABC	1.9377	6	0.3229	0.562	0.761	
BCX SW.G	62.0719	108	0.5747			

A = Smoking Treatment
B = Velocity
C = Blocks

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